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The War Effort of Australia

Last week, a few details were given of the gigantic efforts which Canada is making towards the successful prosecution of the war. Australia, the industrial development of which during the last twenty-five years has been truly phenomenal, is now in the position of being independent of metallurgical imports and can, and is, making a magnificent contribution in both men and materials for any coming offensive. During the last war, Australia had to rely very largely upon imports for the conduct of her metallurgical, mining and agricultural industries. Since that time, such progress has been made, especially by such concerns as the Broken Hill Proprietary Company, the Commonwealth Steel Products, Baldwins, and others, that Australia is almost self-satisfying. Moreover, the secondary industries have attained such dimensions that Metters, Limited, claims to be the largest firm of vitreous enamellers in the Empire.

The production of £50,000,000 worth of munitions, involving the employment of 150,000 men and women, has begun. At the moment over 16,000 are engaged in the production of munitions—a figure six times as great as during the peak period of the last war. Already, there is a notable acceleration in the manufacture of small arms, explosives, bombs and mines. The Broken Hill Proprietary are spending several million pounds on the construction of an additional blast-furnace and shipbuilding yards. From existing yards, construction is being rapidly expanded, and will soon be in a position to launch a ship a week. This production includes a number of patrol vessels which are being rushed to this country. An additional boom vessel, the fourth, is being built for the defence of Darwin at a cost of £145,000.

The Royal Australian Air Force is co-operating in the Empire air-training scheme, and 2,000 men are going to Canada to complete their courses. Apart from this scheme, the personnel of the R.A.A.F. has been increased to 5,400, as compared with 2,000 a year ago. For the last ten months an Australian squadron consisting of 200 officers and men has been on active service with the Coastal Command of the R.A.F. Reinforcements, mainly technicians, have since arrived in the United Kingdom. By 1941, between 8,000 and 10,000 men are likely to be engaged in the manufacture of aircraft, the Government having launched a plan to spend £A25,000,000 on aircraft construction and maintenance. Amongst contracts signed, there are orders for £A1,600,000 worth of Bristol Beaufort bombers; £A800,000 for Wirraway second-line fighters; £A300,000 for North American trailers adapted to Australian conditions by the Commonwealth Aircraft Corporation; £A525,000 for Tiger Moth biplane trainers, and £A45,000 for Moth Minor low wing trainers. About 80 Lockheed Hudsons have arrived from the U.S.A. for home service. The Dominion factories are supplying 50 Moth Minor trainers, 350 Tiger Moth airframes, and 500 Gipsy Major engines.

Practically all ammunition and armament for the Australian armed forces are now being made in Australia. The munition factories are working three shifts a day, and are being rapidly extended. Four new munition factories are to be set up before the close of this year, whilst annexes for the production of war material have been set up in a number of railway shops and private engineering works throughout the Commonwealth. This effort will increase, so that by 1942 17,000 people will be directly engaged in supply and munition activities in Australia, but many more thousands will be employed in aircraft construction, in defence works, and in private enterprises supplying defence orders. Efforts are being made to make within the Commonwealth the machine tools necessary for the manufacture of munitions hitherto imported. For instance, moulding machines are now being made in Sydney in large quantities. Amongst other additional expenditure is one of £A500,000 for the extension of plant to produce new types of guns and explosives such as anti-aircraft and anti-tank guns of increased range. The estimated total war expenditure in Australia and overseas in 1940-41 is over £A110,000,000.

It should not be thought that the whole of Australia's war production is being consumed in the southern hemisphere, as overseas orders were recently announced to be £6,866,000, and included the U.K. Ministry of Supply, £5,000,000; Admiralty, £1,500,000; New Zealand, £260,000, and India, £100,000. It will be obvious from the above that Australia is making a whole-hearted contribution to the Empire's intensive war effort.

C

Organisation of Research

At a conference of the Association of Scientific Workers in Glasgow held on September 21, Prof. W. Wynn Jones, University College, Dundee, addressed the gathering on the "Organisation of Research." He said that it was often remarked that science was necessarily an activity which could not be organised. That was stated quite frequently by eminent and distinguished people. In fact, if one asked eminent academic scientists in the country one would probably find that a majority would reply that science is not an activity to be organised; that it is an activity to be left to the individual. It was that conception which he (the speaker) very definitely challenged. It was his belief that it was essential that science should be organised.

There were in scientific work three main branches of activity—teaching, research, and industry. Everyone admitted that teaching and industry must be organised, but there were some people who refused to admit that research should be organised. He would suggest that such people were a trifle of 50 years or so behind the times. They had not wakened up to the fact that no activity could be carried out to a high pitch without organisation.

Continuing, the speaker said that the real object of organisation was to get something done more smoothly. He believed that it was really the essence of organisation, more particularly of a highly specialised activity such as scientific work, that the organisation should be based upon the individuals actually doing the work, and that it should be closely related to local conditions. There were some people who assumed that it was appropriate that all research work should be segregated, that it should be in research institutions which would be divorced both from Universities and from industry. In his experience that would be a disastrous step. If one had a research institution by itself there was a marked tendency for the workers in that institution to fall into the category of experts. Each man was considered an expert in his own particular subject, and others who had not regarded themselves as experts in that field were afraid to criticise, and consequently there was a tendency for the individual expert worker to be regarded as a little tin god and the work suffered. If the research institution was connected with industry there was an immediate check on the research worker, for if his work was good on the technical side it could be applied, and if it was useless nothing could be done. If, on the other hand, it was related to a University, one usually found that, with the well-known arrogance of University people, the so-called expert was readily criticised.

Referring to the problem of the organisation of scientific work in time of war, Prof. Wynn Jones was of opinion that it was still correct to say that it had not been seriously tackled in this country. He did not mean to say that a tremendous amount of work had not been done on problems in connection with the war, but there had been no complete organisation of scientists for war work.

Regarding the post-war period the speaker said that when the war was over there would be other problems facing us, and he thought that these would be some of the stiffest that ever had to be faced. Whatever did come after the war, there was at least the strong probability of there being a considerable displacement of labour, including the labour of the scientists. The problem was to switch over from war work to work in time of peace.

It would be a big problem to find activity for all the people now engaged upon the war. The future was something that could not be left unplanned.

Control of Civil Building and Constructional Operations

A memorandum has been issued by H.M. Office of Works explaining the way in which it is proposed to administer Defence (General) Regulation No. 56A. This Regulation establishes a system of licensing building and constructional operations and comes into force on October 7, 1940, after which no work or building or civil engineering construction will be permitted in the United Kingdom without consent to undertake or complete such work being first obtained. In general, consent must be obtained for work of any of the following categories:—(i) The construction, reconstruction or structural alteration of a building; (ii) the construction, reconstruction or structural alteration of any railway line or siding, tramway, dock, harbour, pier, quay, wharf, canal, inland navigation, tunnel, bridge, road, viaduct, waterworks, reservoir, pipe-line aqueduct, sewer, sewerage works, gas undertaking, or other fixed works of civil engineering.

No consent is, however, required in the following cases:—(i) If the estimated cost of undertaking or completing the work involved does not exceed £500; (ii) if the work is being done on behalf of a Government Department or in pursuance of a contract for the work made with a Government Department; (iii) if a Government Department has agreed to pay the cost, either in whole or in part, of the work involved; (iv) if the work is being done by a local authority in discharge of its functions under the Civil Defence Acts, 1937 and 1939; (v) if the works are in the nature of maintenance, running repairs or decoration; (vi) if the work is in connection with public utilities or for a local authority, or the carrying on of mining and quarrying operations, and is in progress on October 7, 1940.

In the case of building or constructional operations already in progress on October 7, 1940, and in which the estimated cost of completing the work exceeds £500, application for a licence to continue should be made within 14 days, *i.e.*, not later than October 21, 1940. If this is done, the execution of the work may proceed until the application has been disposed of, either by the issue or the refusal of a licence. An authorisation to continue is not required in respect of any work connected with public utilities or for local authorities.

It will be a defence for a person charged with an offence against the Regulation to prove that, immediately before the commencement of the operation in question or, where the operation was commenced before October 7, 1940, immediately before that date, he had reasonable ground for believing that the cost of the operation, or the cost of completing it, as the case may be, would not exceed £500.

If a person is required by or under an enactment to execute any work of building or civil engineering construction in respect of which an authorisation or licence is required, then, provided that such person has made due application for an authorisation or licence, he will not be treated as having failed to execute his statutory obligation if the failure is due to the refusal of his application or to the imposition of conditions or limitations in the authorisation or licence.

The Gillette Safety Razor Company of America have perfected a method for evaluating the efficacy of abrasive stones. The method is described in "The Iron Age" by David H. Harris, of the Gillette Company.

Random Shots

Everyone is familiar with the opinion often expressed by the fatalist who thinks that if his name is written on a bomb nothing will save him, but Mr. F. J. Cook tells a story of a friend who found a shell band in his garden one morning, after a night raid, which he vowed had his telephone number on it!

* * *

An Army officer to whom "Marksman" was chatting the other day also apparently believed in the myth of the bomb with one's name on it. It happened that he had the good fortune to arrest the crew of a Nazi plane that had been brought down, the pilot of which spoke good English. He was therefore able to ask him quickly what he had done with his bombs, and was told that they had been unloaded just previous to being shot down. The German airman pointed in the direction in which they fell, so the officer lost no time in hastening off to the spot. There he found a bomb which had not exploded, so, before the engineers had time to put it out of action, he calmly took a pencil out of his pocket and wrote his own name on it. "That's the bomb with my name on it, out of action anyway," he thought.

* * *

Suggested opening of any speech at any Branch dinner of the I.B.F. not to be held this coming winter . . . "Whilst the Germans are living up to their ancestral traditions—those of the vandals from whom they sprung—everyone is proud to know that the men of the foundry industry are showing what they know of mettle, which is a great deal . . . ."

* * *

A Little Maiden's Prayer

"And, please God, look after the little children who live at Random, 'cos the Germans seem to drop an awful lot of bombs there."

* * *

Strange, but true . . . that every Nazi plane brought down in this country is an invisible export.

* * *

The "book of the month" is surely one just published under the title of "The Louse," for who could think of a subject more calculated to tickle its reader to death? It is a ticklish thing to write about from another point of view, for one reviewer at least looks as if he might have let himself in for a spot of bother. "The author's own contributions to the literature of the louse," he writes, "enhance the value of the work." "This book," he goes on, "gives a full account of the normal habits and life history of the insect." Anyone who was in the trenches during the last war, of course, need not read it, unless it be to verify the facts as from "one as knows."

* * *

Which reminds "Marksman" of the story of the little girl who was ashamed to tell her teacher at school what was the matter with her mother who was ill in bed. She confided to her dearest friend, however, that "Mummy's in bed with fleabitis."

* * *

This week's best crossword clue comes from the "Daily Telegraph" puzzle. It reads: "A suitable present from a husband to his wife who has just announced the disposal of two houses." The answer is "Bracelet."

"Marksman."

Porosity in Aluminium-Alloy Castings*

By the very nature of the fundamental technique employed in the production of light-alloy castings, namely that of introducing the molten material into a form of pre-determined design and there allowing it to solidify, it is at once evident that the perfection of the final castings will be conditioned by many factors. Some of these factors are relatively easy to control; others are difficult, if not impossible. Among these factors may be cited: The composition and initial condition of the alloy to be used; the procedure adopted for melting; the care exercised in rate of heating; temperature control; duration of maintenance in the molten state; technique of pouring; size and design of mould; type of casting being produced (*viz.*, sand-casting, gravity die-casting or pressure die-casting). These conditions apply to a greater or less degree whatever the material being cast. Light alloys are not peculiar in the exhibition of porosity troubles; many heavy-metal alloys are far more prone to cause difficulties in this respect.

Characteristics Peculiar to Light Alloys

Nevertheless, the characteristic chemical, physical and mechanical properties of aluminium alloys confer to some degree special features upon the various forms of porosity and analogous defects which, in the cast form, may occur in them.

Thus, the low specific gravity of the alloys offers little impedance to the blowing back of mould gases (including air and steam) into the melt. The comparatively low temperatures at which aluminium alloys melt stand in marked contrast to the high melting point of the oxide, which will, if entrapped, show no tendency to escape to the surface in either the liquid or solid form, because of its possessing in addition a specific gravity similar to the metal itself. Many of the alloys are hot-short at temperatures just below the point of solidification; consequently any restraint imposed by unyielding cores, etc., may readily lead to tearing and the formation of obvious or incipient cracks. Pronounced casting shrinkage demands adequate feeding, with particular attention to the number and location of risers and to gating in castings characterised by the possession of wide variation of section. Failure to make allowances for this fact will tend to result in excessive wastage due to draws in sand- and gravity die-castings, although less trouble can be expected in pressure die-castings.

Incidence of Porosity Troubles

Bearing in mind the factors summarised above, it will be of value, before proceeding to a detailed examination of the methods by which the precautions they imply may be implemented, to assess the degree to which porosity troubles may be anticipated in the founding of aluminium alloys.

At the moment, complete elimination of the difficulty has not been attained, but, so rapid has been the progress made during the past five or ten years that, even on comparatively small outputs of ordinary work, wasters have been reduced to a fairly common level of 5 per cent. On massive and long-continued outputs of a given casting, however, a figure as low as 0.75 per cent. is sometimes said to have been arrived at. On castings where severe tests for pressure-tightness must be passed, wasters may average 10 to 15 per cent.

Intensive research now being carried out is making itself felt in remarkable improvements, not only in the inherent high strength of many castings but, more important, in uniformity of quality in mass outputs. These advances are reflected in the gradually widening fields of application of castings (which, in certain directions, are beginning to challenge in popularity the hitherto indispensable, but more expensive wrought forms), and in the economical casting of intricate "one-off" jobs.

The development of new casting alloys, the improvement of existing compositions, and the evolution of a sound technique of light-alloy founding promise in the near future to remove all remaining doubts. The factors already referred to form part of the framework of this knowledge. These will now be examined in detail with reference to the avoidance (or, in special cases, to the control) of porosity due to gas, drawing, and to the elimination of certain general difficulties due to inclusions, hot tears, and scruffing.

It will be necessary, at a later stage, to differentiate between the relative incidence, under any given conditions, of these defects in sand, gravity, and pressure die-castings respectively. However, the points to be immediately examined apply, although in varying degrees, to castings of every form.

Influence of Alloy Composition

The silicon-aluminium alloys, characterised as they are by excellent fluidity and freedom from hot-shortness, exhibit reduced tendency to internal shrinkage porosity, especially if the composition is close to the eutectic. Broadly, similar remarks apply to those silicon-bearing alloys containing minor additions of other elements added to give increased strength or to make them more responsive to heat-treatment. Generally speaking, the silicon group is, when correctly handled, among those best adapted to the production of leakproof castings.

Binary aluminium alloys containing copper show, in the lower copper range, somewhat pronounced hot-shortness and a high casting shrinkage, features liable to lead to draws and to hot tears. With increasing copper, however, these tendencies diminish. The high-strength copper-containing alloy with Cu 4 per cent., Ni 2 per cent., Mg 1.5 per cent. (Aluminium Union Limited alloy 218 or "Y' alloy) may, on account of its relatively high magnesium content and tendency towards internal shrinkage, present some difficulty in the production of sound, pressure-tight castings. It tends to flow sluggishly, thus increasing the possibility of gas entrapment, whilst the preferential oxidation of the magnesium may, unless gating and pouring technique be carefully watched, lead to dross inclusions.

Alloys containing magnesium as the principal alloying element are, with contents of this metal above 1 per cent., very prone to cause trouble due primarily to dross inclusions and to rather marked hot-shortness, these faults tending to increase with increasing magnesium. When undertaking the casting of the 10 per cent. magnesium alloy, the technique best adopted is that evolved for magnesium-base alloys, which require especially liberal feeding.

The popular binary zinc-aluminium alloys exhibit the dual disadvantage of marked hot-shortness and high shrinkage; consequently, to prevent cracking, particular attention must be paid to coring, whilst mould design and feeding must be carefully attended to.

Selecting Alloys for Particular Applications

From this *résumé* it is apparent that in the choice of any particular alloy for a given purpose consideration must be given to the possible existence of residual defects. For example, excellent as are the properties of "Y" alloy in every other way, the considerable risk of its showing some degree of porosity must always render its successful use for pressure-tight castings rather problematical.

No hard and fast rules can be laid down, however, as provided the output envisaged is sufficiently large, there are certain methods by which even the worst defects may be tackled and largely minimised.

Initial State of Metal

The initial condition of the metal to be melted and cast should be considered from two aspects. If the castings are to be produced from virgin ingot and provided this has not become contaminated during transport or storage, no difficulties need be anticipated. If, however, the shrinkage cavity of the ingot has been allowed to become a receptacle for grease, carbonaceous dust, or moisture, then there is more than a

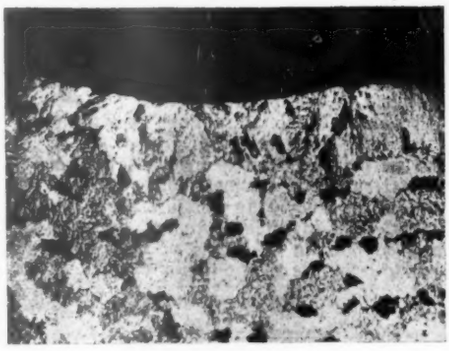


Fig. 1.—Diffused Porosity in Cast Aluminium Alloy due to Gas Evolution during Freezing.

Fig. 2.—Two Views of a Casting showing Draws due to Incorrect Die Design. They were eliminated by Redesigning the Die. (By courtesy of Foundry Services, Limited.)

* Slightly abridged reproduction of an article appearing in the July–August bulletin, "Aluminium Technique," of Aluminium Union Limited. The courtesy of the Editor of the bulletin in according permission to reprint is gratefully acknowledged.

possibility of a gassy melt resulting. If attempts be made to produce castings directly from such a melt, without taking appropriate steps to eliminate the gases before pouring, blowholes or pinholing will occur.

Scrap, however, purchased probably from outside sources and remelted at once for casting, must be carefully scrutinised to determine its freedom from undue oxidation due to bad storage, and particularly to determine the absence of such contamination as cutting compounds, which might lead to the introduction of steam into the melt, with consequent gas absorption and porosity in the final casting.

The necessity for controlling all heavy metal contamination in scrap for remelting is obvious. Such foreign matter is liable to produce unwanted variations in analysis, rather than actual defects of the type under discussion. Oxide contamination, if not removed, will, of course, result in defects due to oxide inclusions in the finished casting.

Melting Practice

The points so far considered, important as they are, must rank as subsidiary to those concerning melting practice and the associated problems of temperature control. No matter what alloy is being melted and no matter how perfect mould design and pouring technique may be, bad melting will always result in porous and defective castings, the trouble being mainly due to gas absorption.

It is not proposed to enter here into a detailed discussion upon the relative merits of various heating media employed for remelting metal for casting. In this country and in America oil-fired furnaces are definitely preferred to other systems. The reasons for this are primarily of an economic nature, coupled with the technical advantages of simple and accurate temperature control. However, systems other than those based on oil-firing are quite extensively employed. Theoretically, at all events, electrical heating should be superior to all other types by reason of the lack of any products of combustion liable to cause contamination of the melt. Similarly, coke-firing for small furnaces presents some difficulty in the way of temperature control, but enables the production of sound casting on an economic basis as long as the coke used for firing is kept strictly dry.

Current practice in this country has, presumably on economic grounds, extended so far no great welcome to any of the available electrical-heating systems. Although coke-firing for small units is gradually being displaced by oil, perfectly satisfactory castings are being produced from melts run down in coke furnaces.

For furnaces other than those of the electric type, it is essential that the design be such that contamination of the charge by products of combustion is virtually rendered impossible. Furthermore, in putting a furnace into operation, adequate precautions should be taken to see that all moisture has been drawn out of the furnace refractories and from the crucible (if this be not of cast iron) before a working charge is run down.

By far the greater part of the porosity encountered in defective castings is, as stated, due to gas, principally to hydrogen absorbed as such, and from steam, which is decomposed in the presence of molten aluminium. On these grounds, therefore, reverberatory furnaces cannot be recommended for the melting down of aluminium for casting purposes. Where pot furnaces are used, the design should be such that combustion gases cannot reach the surface of the melt by passing above the rim of the crucible. The elimination of gas absorption by attention to these points goes far to eliminate subsequent difficulties due to blowholes or gas porosity.

Temperature and Time Factors in Melting

Irrespective of the melting system employed, three factors must be borne rigidly in mind when melting down metal for sand and gravity die-casting. First, the charge should be run down at a reasonably rapid rate to avoid, in the heated (but solid) state, undue exposure and possible contamination. Secondly, it should be heated only to that temperature above its melting point which experience has shown essential in order to attain ideal pouring conditions for the prevailing section of the casting, or for the particular size of casting under production. Finally, the melt having been brought up to the required temperature, it should not be allowed to "stew" for any longer period than necessary.

An average pouring temperature for all aluminium alloys may be taken to be about 700 deg. C., but, as indicated, this will vary not only with the prevailing section of the casting, but also with its size. An upper limit of 780 deg. C. has been quoted for thin-walled castings to be produced in certain of the more difficult alloys, whilst 675 deg. C. has long been given as the lowest permissible figure, this being applicable to castings of the largest size. Eutectic silicon alloys, which are subjected to modification with sodium or sodium salts, must be heated to about 750 deg. C. for the purpose, and then allowed to cool to about 730 deg. C. before pouring.

From previous remarks regarding the tendency of molten aluminium to absorb gases (this tendency becoming more pronounced the greater the degree of overheating), it is at once obvious why melts should not be maintained for unnecessarily long periods in the molten condition when once they have reached pouring temperature.

It might be thought that the holding furnace contravened this advice. On the other hand, this type of furnace is designed merely to maintain a relatively small supply of metal obtained from a larger melting unit proper, the supply being constantly removed, say, for the production of gravity die-castings and renewed at intervals from the main unit. Strict temperature control is exercised over such holding furnaces, and operatives are instructed, when ladling out metal, to do so in such a way as to cause the minimum turbulence of the molten metal. In this way the entrapment of oxide or dross and the driving of air into the melt are largely avoided.

Apart then from the use of a suitable type of furnace for melting the alloys, it is obvious that accurate pyrometric control must be maintained at every stage in the process, if the required degree of perfection is to be obtained in the finished castings. Bare-wire thermocouples of the immersion type are indispensable in that, possessing little or no time-lag, they give immediately the true temperature of the bath. Incidentally, cold shuts, caused by the use of too low a pouring temperature, are of relatively infrequent occurrence in light-alloy castings; the use of excessive temperatures tends to be a much more common fault.

Removal of Gases from Melt

Where gas contamination is suspected, or even as a routine precautionary measure, the practice of pre-solidification is sometimes adopted in order to remove this unwelcome type of contamination. It consists of allowing the melt just to solidify in the pot, under which condition gas, being far less soluble in the solid metal, escapes, and then rapidly to remelt to the correct temperature and pour at once. In the case of the high-silicon alloys, degassification may be achieved prior to modification, by the addition of 2 to 3 per cent. sodium salts, after which further sodium salts or metallic sodium are added for the purpose of modifying the structure.

The degassing of virgin aluminium-alloy melts by the use of chlorine, or certain volatile inorganic halogen salts, finds little application in normal foundry work, it being adopted, as a rule, only for such special cases as the production of some types of cast rolling slabs or extrusion billets. The reagents employed eliminate harmful gases and at the same time do not themselves remain in the metal.

In the case of all-scrap melts such gas treatments might sometimes be adopted with advantage, but such practice is seldom used in view of inherent difficulties of the process. Where scrap forms a considerable portion of the charge, fluxes may be employed to remove included dross which would otherwise be transferred to the casting; a number of proprietary compounds are available for the purpose.

Gas porosity commonly takes the form of micro-internal shrinkage, blowholes, pinholes, shrinkage cavities, the extent of which it is not always possible to determine from the examination of the surface as cast. Blowholes caused by the entrapping of air or mould gases are usually of larger size, and frequently occur at those parts of the casting where some complexity of shape favours the formation of an air lock. The latter type of defect may readily be avoided by adequate venting, coupled with the use of correct grades of sand in the case of sand castings.

Porosity in Pressure Die-Castings

Pressure die-castings are peculiar in that they invariably exhibit a perfectly dense pore-free surface, but may sometimes, especially in large work, be more or less unsound in the interior. This porosity, which commonly takes the form of uniformly distributed minute holes, must be attributed to entrapped air.

Provided all the precautions previously suggested have been observed, gravity die-castings tend on the one hand to exhibit fewer obvious defects than sand castings, and a far less pronounced tendency than pressure die-castings to internal (and invisible) porosity. It should be observed that, in all forms of casting, chilling tends to minimise gas holing.

(*To be continued.*)

Institute of Fuel

FORTHCOMING LONDON MEETINGS

A meeting of the Institute of Fuel will be held on Tuesday, October 8, at 2.15 p.m., in the Connaught Rooms, Great Queen Street, W.C.2, when a Paper will be presented by Mr. W. Boon, of the London and Counties Coke Association, entitled "Some Thoughts on Coke," which will be followed by a discussion.

On Thursday, October 17, at 2.15 p.m., in the Connaught Rooms, a meeting will be held, when Mr. W. M. Selvey, M.Inst.C.E., M.I.Mech.E., M.I.E.E. (who has been the Acting President during Lt.-Colonel J. H. M. Greenly's absence abroad), will present an address to the members present. It is hoped that the President will be in the chair and announce the name of the Melchett Medallist for the current year and present the Student's Medal for 1940.

The above meetings will each be preceded at 12.40 for 1.10 p.m. by an informal luncheon in the Connaught Rooms, where there is an approved air-raid shelter for 2,500 people.

Catalogue Received

Welding Service. Barimar, Limited, of 14, Lamb's Conduit Street, London, W.C.1, and elsewhere, have sent us a 32-page booklet, which illustrates and describes a large number of machinery parts they have reclaimed by welding. In most cases, pictures are given of "before" and "after" welding. A service of interest to foundry owners is the welding of castings accidently broken in transit from the foundry to the customer.

Sulphur in the Cupola

By COLIN D. ABELL

One of the most important aspects of remelting irons in the cupola furnace is the increase in concentration of the sulphur in the iron melted. Usually one or more pig-irons are mixed with returned scrap, and, in certain cases, steel scrap bought in the open market, to give an iron approaching as closely as possible to the desired composition. In calculating the proportions of each constituent for the charges to be melted it is usual to make an allowance for this increase in the sulphur of the melted iron except, perhaps, in those cases where the actual amount of this sulphur in the iron is not of any consequence or where, alternatively, some process of refining or desulphurisation takes place in the ladle.

According to all accounts ferro-manganese has been used for this purpose since about 1880 and contemporary experiments with soda ash proved useful, but were not carried out in many cases from a commercial point of view. It was not until the last decade that the question of desulphurising molten irons by means of soda ash was again taken up and shown to be a feasible method for certain types of irons. Even now the process is imperfectly understood and for many years to come the majority of foundrymen will still use the experience gained to pre-calculate the increase in sulphur and attempt to control the results obtained by the usual routine analyses of the castings or of test-pieces.

Perhaps, therefore, a short outline of what appears to take place in the cupola might be considered as helping to guide the founder in making any alterations in a calculated mixture in order to reduce the effects of the sulphur which cannot be obtained by simple mixing of the available irons in the stockyard.

Methods Available

Actually, there are several methods which may be adopted and which have all given very satisfactory results at one time and another. They include (1) the use of ferro-manganese, either in the burden or in the ladle afterwards; (2) the use of an artificially produced slag which is incorporated in the charges; (3) the use of a certain amount of the following, either together or singly—lime and/or limewashed coke, blast-furnace slags, soda ash, or even common rock salt; (4) the use of soda ash in the ladle; or (5) increasing the amount of slag produced by the furnace, altering its composition, and running the furnace more slowly.

All these methods are satisfactory, provided the founder is in full possession of the knowledge necessary to each modification of the usual process, but each and every one of the processes depend upon two things:—(*a*) The distribution of the sulphur between the gas-phase (sulphur dioxide), the iron (ferrous and manganous sulphides), and the slag (calcium sulphide); (*b*) the partition coefficient of the sulphur between the iron and slag or, in other words, the slag/iron ratio by weight. This partition coefficient of the sulphur between the iron and slag is given by the ratio (percentage of sulphur in the slag)/(percentage of sulphur in the iron), and a very little thought will show that this is a variable, since the amount of slag produced is also a variable quantity. It is found, for instance, in the cupola furnace, that the sulphur, which is always present in the cokes used, is partly burnt or oxidised to sulphur dioxide gas, with which most furnacemen are familiar owing to its powerful effect upon the breathing. The remaining part of the sulphur is distributed according to certain definite laws between the molten iron and slag in the hearth of the cupola.

Influence of Furnace Conditions

It has been found that in practice from 40 to 60 per cent. of the sulphur present in the coke is thus driven off as sulphur dioxide in the waste gases. The higher the amount of carbon dioxide formed in the hearth or, what is the same thing, the greater the amount of air used to blow the cupola, the greater the amount of sulphur driven off as sulphur dioxide. Under most conditions of operation the amount of sulphur driven off in this way is about 58 to 60 per cent. At the same time, the higher the state of oxidation of the carbon to carbon dioxide and the higher the amount of sulphur dioxide produced, the smaller is the amount of sulphur carried by the slag and the greater the amount that enters the molten iron.

This is largely due to the fact that an oxidising atmosphere in the hearth of the cupola causes the production of a slag containing very large proportions of ferrous oxide due to oxidation of the iron and which represents an undesirable loss of metallic iron; the higher the amount of iron oxide in the slag, the less sulphur can it carry as calcium sulphide. In other words, by over-driving the furnace by using the minimum amount of fuel and the maximum amount of air, the greater is the amount of sulphur picked up by the iron. Hence a high rate of driving is inimical to the best interests of the founder and should be avoided. On the other hand, reducing the amount of air, ensuring that there is the maximum amount of carbon monoxide in the hearth possible under these conditions, and at the same time increasing the amount of slag used reduces the amount of sulphur dioxide formed, but enables the slag to carry much more sulphur as calcium sulphide. An increase in the amount of the slag produced by the furnace by about one-third is sufficient to reduce the sulphur pick-up by as much as 40 to 50 per cent., according to the rate of driving.

Possibly most of the trouble with high sulphur pick-up can be traced to excessive air or, what is much the same thing, a deficiency in fuel. It is in this connection, perhaps, that most founders do not realise the real effects produced by the Poumay or the balanced-blast cupolas—that complete combustion of the carbon of the coke is brought about in stages, increasing the efficiency of the furnace, because the metal in the charges reaches the hearth at a much higher temperature than in the usual type of cupola furnace, requires less fuel to bring it to the desired temperature, and confines the oxidising conditions, which are fatal to good practice, to small zones around the tuyeres.

Oxidising conditions are useless in the hearth of the cupola furnace when one takes into account the metallic losses thereby sustained and the large increase in the sulphur in the iron, owing to the fact that the oxide slags produced possess practically no power to carry the sulphur as calcium sulphide under these conditions. As regards the distribution of the sulphur which is not oxidised to sulphur dioxide, but is present in both the molten iron and slag thereof, very little will be said here except to point out the results which can be expected.

Metal-Slag Equilibrium

It is well to remember that a molten iron is in a state approaching to equilibrium with the

(*Continued at foot of next column.*)

(*Continued from previous column.*)

contiguous molten slag, and it has been found that the amount of sulphur in the slag bears a definite ratio to that found in the molten iron, which is dependent upon the amount of slag present. These two factors, the slag/iron ratio and the partition coefficient (as it is called) of the sulphur, are interdependent and are affected by the state of oxidation in the high-temperature zones, since this latter condition determines the amount of sulphur retained in the molten iron and slag together.

Maximum Sulphur Solubility

A subject of great fundamental importance, but one which cannot be outlined here, owing to lack of space, deals with the effects produced by alterations in the composition of the slag upon these ratios. Briefly, the results are that there is a maximum limit of the solubility of the sulphur as calcium sulphide in the slag of about 3 to 4 per cent., whilst there is no limit to its solubility in the iron. Its solubility in the molten slag may be very greatly reduced by the presence of oxides of iron, ferrous and ferroso-ferric oxide, the dark brown and black slags having very little stability in the presence of calcium sulphide, which decomposes them and forms calcium-iron silicates owing to the fact that calcium forms much more stable silicates than iron and can easily displace it in its silicates. Hence, the very useful results obtained by increasing the amount of slag produced by adding larger amounts of limestone, though a mixture containing dolomite and bauxite is preferable in many ways which cannot be outlined here.

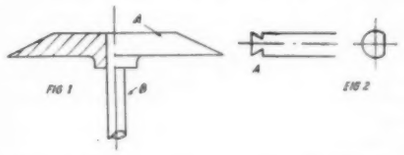
E

Some Jobbing Foundry Experiences—VIII

By "TRAMP"

Castings are occasionally required by the farming community to recondition their implements, and a job of this nature is shown in Fig. 1. This consists of a disc of cast iron A and a wrought-iron or steel shaft B. The problem presented to the jobbing founder is to attach these in such a manner that they always remain rigid. Several methods have been adopted, such as screwing the bar into the cast disc, forming a flange on the shaft and securing with set-screws, etc. Both of these methods have failed because of either the screw working loose or the set-screws shearing off.

The solution of the difficulty lies in casting the spill on to the disc. This presents another problem—how to hold the spill in the disc so



that it remains secure in the correct position after use? The best way to accomplish this appears to be to turn the end of the spill in the form of a dovetail and cut off one corner as shown in Fig. 2. This prevents the spill from pulling through and also from twisting. A pattern is made for the disc and spill and moulded spill down. Prior to casting the spill is placed in the space prepared for it with end A protruding into the mould. The job is run directly on to the centre for two reasons, one being to avoid interfering with the knife edge of the disc and the other partially to fuse the spill and ensure it uniting with the disc.

Chemical Analysis of Alloy Cast Iron

By E. TAYLOR-AUSTIN, F.I.C.

(*Continued from page* 202.)

Aluminium

This element is a very recent addition to the sphere of alloy cast irons. The need for its accurate determination in amount up to 8 per cent. has given rise to a detailed study of available methods of analysis,[2] which has resulted in the evolution of an extremely accurate though somewhat lengthy procedure, in which the aluminium is finely precipitated as its complex with 8-hydroxyquinoline. This investigation has shown that whilst the standard phosphate method may be used for the determination of the residual aluminium content of steel samples, arising from its use as a deoxidiser, it is quite inapplicable to samples containing alloy additions of aluminium. Results obtained by the phosphate method are invariably low, to such an extent as to render them valueless. Precipitation of aluminium as hydroxide is open to interference from phosphorus and hence neither method is satisfactory.

Considerable work has been carried out on 8-hydroxyquinoline as an analytical reagent and various procedures have been recommended with a view to affecting certain separations of aluminium from such elements as phosphorus, titanium, vanadium and uranium. It has been stated that titanium is coprecipitated with aluminium by the reagent in acetic acid-acetate solution,[3] but the author has shown that, under the conditions laid down in the method under review, this is definitely not the case. Further, it is claimed that chromium is not precipitated. The present work has shown this statement to be erroneous, since a precipitate has been obtained and its composition established.[4]

Various procedures such as precipitation with phenyl hydrazine were studied, but none was found satisfactory for the determination of relatively large amounts of aluminium in cast iron. The method finally evolved involves the removal of iron by means of the sodium bicarbonate separation, followed by precipitation of iron sulphide in ammoniacal tartrate solution, before precipitation of aluminium is made. It may be applied to alloy cast-iron samples of any composition, although slight modification is necessary if chromium is present.

Briefly, the details of procedure are as follow: Five grms. of drillings are dissolved in 100 mls. of 10 per cent. sulphuric acid, graphite carbon and silica are filtered off, and the filtrate diluted to exactly 250 mls. in a graduated flask. If the silicon content of the material is above 4 per cent., the original solution should be evaporated to fumes and the silicon removed in the usual way. After treating the precipitate with sulphuric and hydrofluoric acids, the small residue obtained must be used with potassium bisulphate extracted in 10 per cent. sulphuric acid and added to the main filtrate. From the graduated flask 50 mls. (*i.e.*, 1 grm.) are removed by means of a pipette for samples containing between 0.5 and 2 per cent. aluminium, or 25 mls. (*i.e.*, 0.5 grm.) for 2 to 8 per cent. aluminium. This solution is diluted to 100 mls. and boiled; then an 8 per cent. solution of sodium bicarbonate is run in from a burette until a permanent precipitate appears, and 4 mls. of bicarbonate solution are added in excess if the sample contains no chromium, or 6 mls. excess if chromium is present. After boiling for one minute the solution is filtered as rapidly as possible and washed with hot water. The precipitate so obtained will contain all the aluminium, together with about 10 per cent. of iron and all the phosphorus. During the separation, great care must be taken to avoid undue oxidation of the solution, to add no more bicarbonate than necessary, and to filter and wash as rapidly as possible. Neglect of these precautions leads to excessive precipitation of iron. For amounts of aluminium in excess of 8 per cent., a larger excess of bicarbonate is necessary.

The precipitate is dissolved off the filter paper, with hot 20 per cent. hydrochloric acid if chromium is absent. If chromium is present it is dissolved off in 50 mls. of hot 20 per cent. sulphuric acid, the solution diluted to 300 mls. and boiled. To this boiling solution 10 mls. of silver nitrate solution (17 grms. per litre) is added, followed by 10 to 15 mls. of freshly-made saturated ammonium persulphate solution, and the boiling is continued for 3 mins. Aluminium is now precipitated by the addition of a slight excess of ammonium hydroxide and boiling is continued until the issuing vapour no longer smells of ammonia; the solution is filtered and the precipitate washed with hot 1 per cent. ammonium nitrate solution and finally dissolved off the paper with hot 20 per cent. hydrochloric acid. This solution, or the one obtained by direct solution of the precipitate obtained by the bicarbonate solution in the absence of chromium, is diluted to about 200 mls., 5 grms. of tartaric acid are added and a rapid stream of hydrogen sulphide is passed for 20 mins. Any elements such as molybdenum or copper will be precipitated at this stage, together with the silver introduced by the chromium separation. After filtering off any precipitate obtained the solution is made ammoniacal, and 1 ml. excess is added. Hydrogen sulphide is again passed for 15 mins. and the precipitated iron sulphide is removed by filtration. A reprecipitation is made after solution of the precipitate, and the two filtrates are combined and evaporated to a volume of 100 mls. Sulphur is removed by the addition of bromine and a further 20 mls. of concentrated hydrochloric acid; excess bromine is expelled by boiling. Most of the free acid is neutralised with ammonium hydroxide, three drops of 0.05 per cent. neutral red indicator solution are added, followed by more ammonium hydroxide solution until a yellow colour is produced. Next, 10 per cent. acetic acid is added until the solution becomes just pink. The solution is warmed to 70 deg. C., and 15 mls. of 2 per cent. oxine solution for every 10 mgs. of aluminium present is added, followed by 50 mls. of 4 N ammonium acetate solution, and after allowing to stand until the precipitated aluminium oxine complex has coagulated (15 mins.), it is filtered on a sintered glass crucible (No. 4 porosity), washed with very hot water, and dried to constant weight at 110 deg. C. The residue so obtained contains 5.88 per cent. aluminium. A somewhat quicker method is to dissolve the oxine complex in 50 mls. of hot hydrochloric acid, dilute to about 250 mls. with hot water, and four drops of indigo carmine solution and run in standard potassium bromate-bromide solution slowly from a burette until a pure yellow colour is obtained. Shake well and allow to stand for 5 mins. Fifteen mls. of carbon disulphide are now added, followed by 10 mls. of 10 per cent. potassium iodide solution and the liberated iodine titrated with sodium thiosulphate solution, using starch as indicator until no blue coloration remains in the carbon disulphide layer. The standard solutions are N/5 potassium bromate containing 50 grms. of bromide per litre and N/5 sodium thiosulphate.

The above method has been in use in the B.C.I.R.A. laboratories for the past eighteen months and has proved to be the most accurate yet devised for the determination of aluminium in cast iron and other ferrous materials.

Titanium

It is very seldom indeed that a pig-iron is encountered which does not contain at least 0.05 per cent. of titanium, but only during the past few years has any importance been attached to the presence of this titanium. Still more recent is the use of titanium as an alloy addition to cast iron. Thus, the accurate determination of this element has become a matter of considerable importance. Provided that such elements as vanadium, chromium, nickel, copper or molybdenum are not associated with the titanium the direct colorimetric method for its determination is sufficiently accurate for all practical purposes. It has been found that this method requires rather more careful manipulation than a study of the available literature on the subject would suggest.

This method has been very carefully examined[5] and a new rapid procedure has been devised to replace the older method of making determinations on the solution remaining after the determination of manganese by the bismuthate method. It is, however, obvious that the colorimetric method cannot be applied in the presence of elements which impart a colour to the original solution or give coloured components with hydrogen peroxide. The chief source of difficulty in this direction is vanadium, which is frequently associated with titanium in pig-iron and which yields a red-brown colour with hydrogen peroxide. It is possible to determine titanium in the presence of small amounts of vanadium by adding an equivalent quantity of the latter to the "blank" solution after a determination of vanadium on a separate sample with the titanium coloration suppressed by the addition of hydrofluoric acid. This method, however, requires considerable experience and becomes inaccurate if the vanadium content of the sample exceeds 0.1 per cent.

Recently, the question of the determination of titanium in the presence of appreciable quantities of vanadium and in cast irons containing nickel, chromium and copper has been studied in detail[9] and a new method has been evolved to meet the situation.

Separation of Titanium from Vanadium

This separation has always presented serious difficulty; the old method of fusion of the mixed oxides with sodium carbonate, whereby the vanadium forms sodium vanadate, which is soluble on extraction, whilst the titanium is hydrolised and removed by filtration, has several disadvantages. In the first place, separation of

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[12] E. Taylor-Austin, "A Platinum-Wound Furnace for the Determination of Sulphur by Combustion," B.C.I.R.A. Research Report 2037A (1940).
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the titanium depends upon the presence of a little iron, and even then is not altogether complete; a small amount invariably passes into the filtrate. Secondly, if relatively large numbers of determinations are performed, at the same time, the separations occupy considerable time unless large amounts of platinum ware are at the analyst's disposal.

During the present investigation an entirely new method of separation has been discovered which is both speedy and complete. It has long been known that if cupferron is added slowly to an unoxidised iron solution containing titanium, the latter is selectively precipitated at the commencement; no iron is precipitated under these conditions until the whole of the titanium has been removed from the solution. This principle forms the basis for the determination of titanium in ferrous materials by cupferron at the present time. Vanadium, if present, is precipitated with the titanium in this method and the general practice now in use is to attempt its separation from the ignited residue of oxides.

The author has, however, demonstrated[5] that if the original iron solution containing titanium and vanadium is specifically reduced by means of sulphurous acid as distinct from merely avoiding oxidation during the decomposition of the material in acid, titanium is selectively precipitated as before, but is also completely separated from vanadium which remains in solution, together with the bulk of the iron. This method of separation applies equally well to solutions containing titanium and vanadium in the absence of iron. Thus titanium and vanadium can be readily separated in one simple operation without resorting to fusion. The separation has been applied to samples containing amounts of the two elements varying from 0.5 per cent. Ti and 0.1 per cent. V to 0.6 per cent. V and 0.1 per cent. Ti, including alloys with 0.5 per cent. Ti and 0.6 per cent. V, and has proved completely successful.

As far as the author is aware, the fact that if vanadium is reduced by sulphur dioxide it forms no precipitate with cupferron whilst titanium is still quantitatively separated, has never before been observed or mentioned in analytical literature. It is therefore of considerable importance as a contribution to the general chemistry of titanium and vanadium from the point of view of the analyst.

It is only on very rare occasions that a gravimetric determination of titanium is desirable, and such methods are both lengthy and complicated. The general procedures at present employed depend ultimately upon the colour produced when acid solutions containing titanium are treated with hydrogen peroxide. The elements which cause interference in this colorimetric method have already been mentioned, but certain other factors must be taken into account if accurate results are to be obtained. Thus, in the colorimetric method in which phosphoric acid is used to suppress the coloration due to iron, sample and standard must contain exactly equal amounts of the reagent owing to its bleaching action on the titanium coloration. Similarly, sample and standard must contain equal amounts of hydrogen peroxide and must be at equal temperatures below 20 deg. C. If the temperature of the solution is raised, the colour fades rapidly.

If a Lovibond tintometer is applied to this determination, its speed is considerably increased, since standards may be dispensed with. It is, however, necessary to adopt an absolutely standard procedure in which exactly the same amounts of phosphoric acid and hydrogen peroxide are used in every determination in order to produce the same relative depth of colour. The dilutions of the solutions should also be standardised.

The recommended procedure for the direct colorimetric determination to be applied only in the absence of vanadium and other alloying elements is as follows:

Dissolve 1 grm. of drillings in 50 mls. of 10 per cent. sulphuric acid, gently heating until solution is complete. Oxidise with a few drops of nitric acid and boil for three minutes. Filter through a pad filter into a 250-ml. measuring flask and wash with hot 2 per cent. sulphuric acid and hot water; cool to less than 20 deg. C., add 10 mls. of syrupy phosphoric acid, 10 mls. of 10-vol. hydrogen peroxide, and dilute to exactly 250 mls. Mix well and pour off the amount required to fill the Lovibond Cell chosen and match against the standard yellow and red slides of the instrument. Alternatively, the solution may be filtered into a beaker, cooled and 3 mls. phosphoric acid added, followed by 10 mls. of 10-vol. hydrogen peroxide; the solution is then transferred to one of a pair of Nessler tubes and matched against a standard, containing equal amounts of iron and the reagents in the other tube by adding standard titanium solution.

For determination in the presence of vanadium the procedure is as follows:

Dissolve 1 grm. of sample in 50 mls. of 10 per cent. sulphuric acid as before, but oxidise with 30 mls. of 10-vol. hydrogen peroxide. Boil for three minutes and filter off graphite, etc.; to the filtrate add a 50 per cent. solution of ammonium hydroxide until a faint precipitate persists. Just redissolve this in 10 per cent. sulphuric acid, add 25 to 30 mls. of sulphurous acid and heat until the solution becomes colourless or pale green. The excess of sulphur dioxide is not removed, since it serves to maintain the solution in a reduced state during cooling. Cool the solution somewhat and then add sufficient sulphuric acid to yield 10 per cent. acidity; cool further to a temperature of 10 deg. C. or less and add a cold 6 per cent. aqueous solution of cupferron from a dropping bottle, with vigorous stirring until the precipitate, which is bright yellow at first, changes to brick red. Stir in a little paper pulp and filter on a Whatman No. 40 paper. Wash well with cold water and ignite in a silica crucible. To the residue add 1 grm. of fused potassium bisulphate and fuse over a burner for 1 to 2 mins. Extract the melt in 100 mls. of 10 per cent. sulphuric acid, cool and dilute to exactly 250 mls. in a graduated flask after adding 10 mls. of phosphoric acid and 10 mls. of hydrogen peroxide. Determine the titanium content of the solution as described under the direct colorimetric method.

Precipitation of titanium with cupferron in the manner described effects a complete separation from nickel, chromium, molybdenum and vanadium. Copper, if present, is precipitated with the titanium, but may readily be separated from it by treating the precipitated complexes with ammonium hydroxide and washing with cold water. The copper-cupferron complex is easily soluble in ammonium hydroxide and is thus removed.

The chief difficulty encountered when dealing with the determination of titanium in alloy cast irons is to obtain a complete solution of the titanium present without resorting to fusion of the residue of graphitic carbon, silicon, etc., obtained during decomposition. The method just described of solution in dilute sulphuric acid followed by oxidation with hydrogen peroxide yields a satisfactory solution with irons containing vanadium and/or nickel, but is inapplicable to alloys of the Nicrosilal and Ni-Resist type and to those containing more than 4 per cent. silicon. It was finally concluded that for irons of these latter types no means of dissolving the whole of the titanium could be established without resorting to fusion of the first insoluble residue. It has long been known that solution of materials in reducing acids such as dilute hydrochloric or sulphuric leaves any titanium or vanadium present in the insoluble residue. Small amounts of titanium are dissolved, but these can usually be ignored if a rapid solution can be obtained. Unfortunately, most alloy irons dissolve slowly in such acids, and hence this method cannot be relied upon to separate the titanium completely.

The only means of obtaining a decomposition of alloy materials which do not dissolve in the sulphuric acid: hydrogen peroxide mixture is to employ concentrated hydrochloric acid. Nitric acid should be absent, since the solution will require reduction in order to obtain selective precipitation of the titanium. The precipitate of silica, etc., is filtered off, ignited and treated with hydrofluoric and sulphuric acids and the residue retained. The final cupferron precipitate is then ignited with this residue and the two are fused together with bisulphate and the determination completed by the colorimetric method.

Vanadium

Methods for the determination of this element have changed little in the last few years. Amounts not exceeding 0.5 per cent. may be determined by the colorimetric method, which is exactly the same as that for titanium, except that the colour due to the latter is removed by addition of hydrofluoric acid. It is not advisable to use a colorimeter, since this acid attacks the glass cells. The standard employed should contain an equivalent amount of hydrofluoric acid. Larger amounts than 0.5 per cent. are seldom encountered in the examination of cast iron samples, but if determinations are required, the volumetric method involving titration with ferrous ammonium sulphate and potassium permanganate may be employed. This method has recently been improved by the use of diphenylamine sodium sulphate as an internal indicator in place of potassium ferricyanide.[6]

Separation of vanadium from such elements as nickel, chromium, molybdenum and copper, if desired, may be made by precipitation with cupferron, as described for titanium, without reduction of the solution, and determinations completed colorimetrically.

Other Elements

Of the remainder of the elements previously mentioned, tungsten and cobalt are rarely encountered, whilst zirconium, tantalum, niobium, arsenic, antimony and tin will generally be found only in very small quantities and determinations are rarely required.

Tungsten is determined by the standard procedure employed in alloy steel analysis, *i.e.*, by precipitation of tungstic acid.

Cobalt is similarly determined by precipitation with nitroso naphthol after removal of iron, chromium, etc., by means of the zinc oxide separation.

Tantalum and Niobium.—The determination of these two elements in pig and cast iron is a matter of considerable difficulty and methods are necessarily long and tedious.[7] The salts of tantalum and niobium hydrolyse so readily that precautions must be taken to prevent their precipitation during the various separations incorporated in the method. Chief among these corrective measures is the use of citric or tartaric acid and hydrogen peroxide. Iron may be separated by precipitation as sulphide from ammoniacal tartrate solution, and tantalum and niobium may then be precipitated with cupferron. The latter precipitate will also contain any titanium, vanadium and zirconium present in the iron.

In his book, entitled "The Analytical Chemistry of Tantalum and Niobium," Dr. W. R. Schoeller describes the separation of these two elements from numerous other elements, including those mentioned above. The appropriate separations, which are all based upon the use of tannin, have been incorporated in the method under review and have been found to function admirably. The ignited cupferron precipitate is fused with potassium bisulphate, extracted with 10 per cent. sulphuric acid and

precipitated with ammonium hydroxide; this removes vanadium. The residue is again fused and extracted in saturated ammonium oxalate solution and the tannin separation from zirconium is applied.[7] This residue is fused with bisulphate extracted with 10 per cent. sulphuric acid and titanium is separated by tannin.[8] For details of these tannin separations, the reader is referred to Dr. Schoeller's book.

The separation of small amounts of tantalum and niobium from one another is an extremely difficult and tedious operation. As far as cast iron is concerned, the separation is seldom necessary. Details of this separation are also given by Dr. Schoeller.[9]

Zirconium.—The method used for this determination is similar to that used in steel analysis, except that the residue of graphitic carbon and silicon must be examined for zirconium. The amount remaining at this stage is small, but increases with the phosphorus content of the iron. The general procedure is to decompose the sample in 20 per cent. sulphuric acid and remove silica, etc., by filtration. This residue is ignited, silica is removed by hydrofluoric acid in the usual manner, and the small residue is retained. Zirconium is separated from the iron in the filtrate by precipitation as phosphate by the addition of 15 mls. of 10 per cent. ammonium phosphate solution. Precipitation of titanium is prevented by the addition of 10 mls. of 10-vol. hydrogen peroxide, prior to the addition of phosphate. The solution is maintained at 70 deg. C. for 30 mins., and is then filtered off, washed with 5 per cent. ammonium nitrate solution and ignited in the crucible containing the small residue from the silica precipitate. The combined residues are fused with 2 grms. of sodium carbonate, extracted with water and filtered. After washing with 5 per cent. ammonium nitrate the precipitate is ignited, fused with potassium bisulphate, extracted in 10 per cent. sulphuric acid and the zirconium precipitated with ammonium phosphate exactly as before. On ignition the residue consists of a phosphate of zirconium containing 38.3 per cent. zirconium. This factor is empirical and does not conform to the formula ZrP_2O_7, but it has been shown by Gregory and Stevenson[10] and confirmed by the author that the composition of the phosphate is definite and the factor is constant.

Arsenic.—This determination may be carried out by dissolving the sample in dilute nitric acid and removing all traces of the acid by repeated fuming with sulphuric acid. This solution is transferred with concentrated hydrochloric acid to a distillation flask containing ferrous sulphate crystals. Arsenic is removed by distillation and collected in water. This distillate is neutralised with sodium hydroxide and then made just acid to litmus with hydrochloric acid. Sodium bicarbonate solution is added and titration is made with standard iodine solution, using starch as indicator.

Antimony.—This element is nowadays used occasionally as an alloy addition to cast iron. Its determination is carried out by separating it from iron by precipitation as sulphide in acid solution. The filter paper and precipitate are treated with a mixture of sulphuric acid and nitric acid and 5 grms. of sodium sulphate. This mixture is heated strongly for 1 to 2 hours to destroy organic matter and is then cooled. After dilution to 250 mls., 20 mls. concentrated hydrochloric acid is added and the solution titrated with N/20 potassium permanganate to a pink end-point. The volume of permanganate used is a measure of the amount of antimony present.

Elements such as molybdenum and copper will, if present, accompany the antimony as sulphides; these may be removed by adding ferric chloride solution and precipitating with ammonium hydroxide. Arsenic is removed if necessary by distillation as in its determination. After the above separations, antimony is reprecipitated as sulphide and treated as in the method proper. Such separations are seldom necessary at the present stage in the metallurgy of cast iron.

Boron.—This element is also used occasionally as an alloy addition at the present time. Two methods are available for its determination: (1) By volatilisation as methyl borate from a solution containing boric acid and very little hydrochloric acid. This ester is then saponified in alkaline solution to obtain sodium borate and alcohol is expelled. Finally the solution is titrated so that only boric acid is present and then the titration is resumed under conditions which yield sodium dihydrogen borate. In this method the sample is decomposed by hydrochloric acid and hydrogen peroxide under a reflux condenser. (2) The material is dissolved in a mixture of hydrochloric and nitric acid under a reflux condenser and when the reaction is complete, the solution is cooled and a large excess of calcium carbonate is added. The mixture is boiled for 30 mins. under a reflux condenser to decompose bicarbonates and remove carbon dioxide. The precipitate is filtered off rapidly, using a Buchner funnel, and washed with boiling water. The filtrate is cooled and titrated with sodium hydroxide solution to a pink coloration using phenolphthalein indicator. Mannitol is then added and the titration continued to a permanent pink end-point. A further quantity of mannitol is added and if the colour disappears titration is continued. A "blank" determination on a boron-free iron and the reagents is necessary.

Of these two methods, the former is the more accurate, but the latter is far simpler in operation and yields results sufficiently accurate for most purposes, as far as cast iron is concerned. Whichever method is used, it should be borne in mind that boric acid is readily volatile in steam and thus solutions containing it should only be boiled under a reflux condenser.

Tin.—The determination of this element is in itself a relatively simple matter, but the usual procedure adopted in general ferrous analysis is complicated by the fact that in the presence of appreciable amounts of phosphorus, such as are encountered in most cast-iron samples, a phosphate of tin is formed during the decomposition of the sample, which remains in the insoluble residue of graphite and silica. The author has shown that in an iron containing 0.5 per cent. Sn and 1 per cent. P, 40 per cent. of the tin present and 9 per cent. of the phosphorus remains in the insoluble residue mentioned, whilst with 1.25 per cent. Sn and 0.025 per cent. P, 4 per cent. of the tin and 32 per cent. of the phosphorus remains. It is therefore obvious that tin and phosphorus interfere mutually in methods for their determination unless precautions are taken. The method finally devised for the determination of total tin in cast iron was as follows:—

Five grms. of sample are dissolved in 20 per cent. sulphuric acid and the insoluble residue is filtered off, washed with hot 5 per cent. sulphuric acid, ignited and retained. The filtrate is boiled and oxidised by addition of a saturated solution of potassium permanganate and the excess of this reagent is removed by sulphurous acid, sulphur dioxide being expelled by further boiling. A rapid stream of hydrogen sulphide is passed through the hot solution until it attains room temperature. The precipitate is filtered off and washed with 1 per cent. sulphuric acid, saturated with hydrogen sulphide. Dissolve the precipitate from the filter with hot 5 per cent. hydrochloric acid and add the filter paper to the reserved residue from the initial solution. Boil hydrogen sulphide from the solution, add 50 mls. of concentrated hydrochloric acid, 1 grm. of powdered antimony and continue boiling for 15 mins. in order to reduce the tin to the stannous condition. Cool in an atmosphere of carbon dioxide and titrate (also in carbon dioxide) with standard iodine solution, using starch as indicator.

The combined ignited residue is fused with sodium peroxide in a nickel crucible, extracted with water and 50 mls. of concentrated hydrochloric acid added. This solution is reduced with antimony and titrated with iodine as before. The sum of the two iodine titrations is the measure of the total tin present.

The above method has been successfully applied to a series of cast-iron samples containing up to 8 per cent. of tin. Copper and molybdenum interfere in this method, but may be readily removed by precipitation of the tin with ammonium hydroxide and redissolving the precipitate in hydrochloric acid for reduction and titration.

Use of Organic Reagents in Inorganic Analysis

It will be noticed that many of the recently devised methods for ferrous analysis employ organic reagents. Many of these reagents have been introduced into analytical chemistry during the past ten years and have afforded the analyst great assistance. For gravimetric determinations they possess several advantages, foremost amongst which is the fact that owing to the high molecular weight of the organic portion of their metallic complexes they form very copious precipitates; this enables small amounts of metals to be detected and determined with great accuracy. The precipitates thus formed filter and wash well and may be dried or ignited according to the nature of the complex involved. Some of them are more or less specific reagents for a particular element. *e.g.*, α-benzoin monoxime in ammoniacal solution for copper; others, such as 8-hydroxyquinoline, precipitate a formidable list of elements, and elaborate separations are necessary before a final precipitation can be made. In spite of this, reagents of the latter class are extremely useful for separations which were at one time both tedious and difficult. Thus 8-hydroxyquinoline separates aluminium from phosphorus, and cupferron separates iron, titanium, vanadium, zirconium, etc., from aluminium and phosphorus. Reagents such as dimethyl glyoxime and α-nitroso β-naphthol are sufficiently well known to pass without comment.

In colorimetric analysis, reagents such as diphenyl carbazide have made possible the determination of minute amounts of chromium. Similarly dithiol provides a colorimetric method for the determination of small amounts of tin. Thioglycollic acid avoids the disadvantages of potassium thiocyanate as a reagent for the determination of iron in materials such as sands and silicates generally. Aurine tricarboxylic acid can be used as a reagent for the determination of aluminium in small amounts, although it has disadvantages in this connection.

Further diphenylamine and diphenylamine sodium sulphonate may be used with great advantage as internal indicators to replace the older external indicator potassium ferricyanide in determinations of such elements as iron and vanadium.

In considering these recent advances in analytical procedure, it should be pointed out that many improvements in the design of laboratory equipment have been conducive to more accurate analysis. Thus the wider use of electrically-heated furnaces, particularly for the combustion of samples for the determination of total carbon and sulphur, has overcome the possibilities of contamination of the issuing gases by sulphur and other impurities. The introduction of the air-damped balances has rendered the operation of weighing more speedy and less tedious. A greatly improved Lovibond Tintometer has recently made its appearance and has helped to put colorimetric analysis on a rather more fundamental basis than was hitherto possible.

(*Continued on page* 230.)

Application of Controlled, Directional Solidification to Large Steel Castings

By J. A. DUMA and S. W. BRINSON, Portsmouth, Va.

(*Continued from page* 207.)

PART 3—SPECIFIC CASES

Anchor Shanks—Control by Banking

Of the many marine castings that the foundry makes, anchor shanks are probably the most adaptable to controlled solidification. They are long, slightly-tapered, solid members of rectangular cross-section with liberally radiused corners. Their design is completely free from re-entrant angles, differential sections, and changes in direction. The absence of all but one small internal core in the shackle-bolt hole also makes for integrity in the subject castings. Fig. 8 depicts the general outline of a shank for a 9-ton stockless anchor, with gate and feed-head attached.

The procedure of mould manipulation involved in directing solidification up the shank is quite simple. The mould is tilted at a small angle (20 deg.) on a bar or rail on the foundry floor so that the ingate and feed-head are located at the low end of the mould. After pouring is completed and the vent sealed, the mould is reversed through an angle of about 20 deg. to bring the feed-head into the requisite superior position in relation to the casting.

Using the above practice, it is possible to produce overall temperature gradients of approximately 380 to 480 deg. C. in the shank. Inasmuch as the efficiency of the feeding or heading system is a function of the temperature gradient imposed on the solidifying metal, it is apparent that whatever can be done to widen the temperature gap between the vertical extremities of the casting will result in a sounder product. In this connection, the following additional steps are taken to secure a steeper heat gradient: (1) Slow pouring; (2) filling feed-heads from the top; and (3) heat-insulating the top of feed-heads.

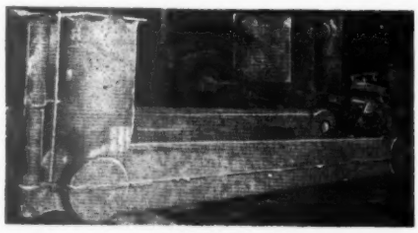

Fig. 8—Shank for 9-ton Stockless Anchor with Gate and Feed-Head Attached.

Slow Pouring

It is not difficult to see how slow pouring creates increased temperature differences. Metal solidifies as a result of transference of heat from itself to the mould. In its transit through the mould, it cools by an amount which is proportional to the duration of its contact with the mould, and the ratio of the contacted mould area to the thickness of the metal stream passing over it. The essential feature of pouring, therefore, is that the moulds shall be filled as slowly as practicable. Too rapid filling of the mould results in greatly reduced temperature gradients, and, oppositely, too slow pouring is productive of castings having a defective surface, scabbed and pock-marked on the cope side.

Scabbing, by slow pouring, occurs in the following manner. The drag or bottom surface of a mould generally escapes injury because the weight of the overlying hot metal overwhelms all lifting and bulging forces generated within it. No such damping action is exerted on the disruptive forces acting on the cope or top surface. Here the intense radiant heat, given off by the slowly rising metal beneath, acts on the cope, causing it to crack and swell. The cracked and loosened surface is then either pulled down by gravity or dislodged by the wiping action of flowing metal.

This burning down of the cope can be remedied in one of four ways: (1) Faster pouring; (2) more thorough nailing of the cope surface; (3) an increased use of crabs in the cope; or (4) strengthening the bond of the sand in the cope with more bentonite. The shank under discussion was poured with approximately 1.0-in. rise of metal in the mould per second. This speed was obtained with a 2½-in. pouring nozzle and a 4-in. ingate.

Casting Temperature

Pouring temperatures which are too low, even if sufficiently high to avoid cold shuts, may not permit risers to perform their primary function of feeding the casting or to carry off slag, dirt and dross. Casting temperatures on the other hand which are too high, apart from increasing liquid shrinkage and apart also from other disadvantages attaching to them, reduce the rate of solidification, because the excess heat of the metal is communicated to the mould before the freezing point of the metal is reached, so that the thermal capacity of the mould is largely exhausted before solidification begins. The resulting very gradual solidification produces not only a very coarse structure, but allows the occurrence of serious segregation. It is, therefore, an almost universal rule that casting temperatures should be kept as low as pos-

Table IV.—*Mould Materials, Steel Data, Foundry Practice and Heat-Treatment for Making Anchor Shanks and Anchor Crowns.*

	Anchor shank.	Anchor crown.
Mould Materials—		
Facing sand (See Table I, Part 1)	No. 2i	Cope : Nos. 3d, 3e Drag : Nos. 2i, 2j
Backing sand (See Table I, Part 1)	No. 4b	No. 4b
Core (See Table I, Part 2)	No. 5e	—
Internal cores (See Table I, Part 2)	—	No. 5e
External cores (See Table I, Part 1)	—	Nos. 2i, 2j
Steel Data—		
Steel grade	Bw	Bw
Pouring temperature, deg. C.	1,580	1,565
Nozzle size, in.	2½	3½
Pouring time (not including riser), sec.	25	55
Rate of metal rise in mould, in. per sec.	1.0	—
Founding—		
Banking angle of mould, deg.	20	—
Temperature gradient obtained, deg. C.*	525	—
Size of feed-head	17 in. rd. × 26 in.	—
Size of ingate, in.	4	4 (terra cotta)
Size of risers	—	2—11 in. rd. × 14 in. 1—24 in. rd. × 30 in.
Weight of shank, riser and gate, lbs.	5,900	—
Weight of shank, lbs.	4,820	—
Weight of crown, risers and gate, lbs.	—	19,300
Weight of crown, lbs.	—	15,500
Heat-Treatment—		
Upheat, hrs.	18	18
Hold, hrs.	30	30
Temperature, deg. C.	900	900
Cooling, hrs. in furnace	24	24

* Measured with thermocouples immersed in metal to a depth of 1 in. in the bottom-most and top-most locations of shank.

Table V.—*Physical Properties on a 9-Ton Anchor Crown (after Standard Annealing Treatment).*

Location of specimen.	Tensile strength. Tons per sq. in.	Yield point.[3] Tons per sq. in.	Elongation in 2 in. Per cent.	Reduction of area. Per cent.	Izod impact.[3] Ft.-lbs.		
Coupon[1]	30.1	18.4	34.0	54.5	—	—	—
Outside[4]	29.2	16.6	28.0	39.1	36.0	37.5	41.5
Midway	29.1	17.9	20.0	25.8	34.0	33.0	34.0
Centre	28.2	17.9	17.0	24.1	39.5	25.0	35.5
Trepanned Specimens Re-Annealed at 900 deg. C. for 2 hrs.							
Outside	30.6	20.1	35.0	54.4	42.5	47.5	41.0
Centre	30.7	20.4	20.0	26.8	45.0	41.0	50.5

Transmissibility of Impact Loads at 80 and 32 deg. F.[5]

Location of specimen.	Single width (10 mm.).	Double width (20 mm.).	Temp. of test. Deg. C.	Heat-treatment.
Outside	23.0	42.5	80	Standard anneal.
Outside	26.0	50.0	80	Trepanned and re-annealed at 900 deg. C. for 2 hrs.
Midway	13.5	15.0	32[6]	Standard anneal.
Midway	18.5	42.5	32	Trepanned and re-annealed at 900 deg. C. for 2 hrs.

[1] Coupon attached to underside of fluke.
[2] Divider method.
[3] 10 mm. square, V-notch, 120 ft.-lbs. setting.
[4] Specimens taken from failed anchor crown.
[5] Charpy-type impact specimens, one 10 mm. square and the other 10 mm. thick by 20 mm. wide. Hammer let fall from 220 ft.-lbs. setting.
[6] Specimens were held for one hour on melting ice, then tested.

Note.—Dimensions of section tested = 9 in. thick by 12 in. wide by 30 in. long.

sible, consistent with adequate fluidity of the metal to allow proper filling of the mould. The approximate casting temperature of the metal used in making the shanks was 1,565 deg. C.

The practice of filling up feed-heads from the top, after the pouring of the casting proper is completed, is further assurance that the metal in the upper levels of the mould will be hottest. Covering the risers with anti-piping material retards their cooling considerably and thus it, too, tends to promote better feeding. The riser on all shanks was treated in such a manner.

The data given in Table IV relate to a shank for a 9-ton anchor. It will be noted that dry steel facing sand and used sand-blast sand were used in making the mould and core respectively. The reason for this is that the relatively harmonious design possessed by the shank presents no problem in mould resistance. Sand-blast sand cores impart a very smooth finish to the casting surface; they are not used where a high order of ready and immediate collapsibility is desired.

Control of Anchor Crowns by Top-Pouring of Risers

Instances where top-pouring is employed, *per se*, as a means to secure directional solidification are rare; instances where it is used conjunctively with other methods are legion. Top-pouring is accomplished in one of two ways: (1) Either the casting together with its risers, or (2) the risers alone, are top-poured. When it is not feasible to pour a casting *via* a top gate for fear of excessive erosion of the mould, the next best procedure is to bottom-pour the casting up to the level of the risers, and then top-pour the risers. The latter practice is the more common.

Concrete examples, illustrating the employment of the latter method for directing solidification, are anchor crowns and large Monel Metal propellers. Both of these castings, by design, are subject to differential freezing. The thin flukes on the anchor and the thin blades on the propeller congeal rapidly, while the more massive sections, particularly the feed-heads, remain fluid for a long time. Even if the above were to be bottom-poured completely, it is apparent that the adverse temperature gradient produced by bottom-pouring would not only be short-lived but would soon reverse itself into a favourable one by the lower surface-area to volume ratio of the heavier base and feed-head sections.

The remarks made under anchor shanks, concerning the speed of pouring, temperature of metal, and mould resistance, also are applicable to the crown. The data shown in Table IV pertain to the making of 9-ton anchor crowns.

Two undesirable conditions attended the manufacture of large (9-ton and 11-ton) anchor crowns, viz., scabbing of the cope surface, and low dynamic strength at 42 to 52 deg. F. in heavier sections.

Navy Department Specification 6A2 for stockless anchors requires that they be drop-tested from a 12-ft. height. The physical strength of the metal of an anchor fluke which failed in cold weather in the drop test is recorded in Table V. Susceptibility to cold brittleness under impact was partially overcome by increasing the holding time, on annealing, from 30 to 38 hrs., together with the employment of approximately 1,000 lbs. of internal chill bars (½ in. thick by 1½ in. wide by 12 to 36 in. long) arranged checkerwise in the flukes. It is the policy of the foundry rarely to resort to the use of internal chills, in fact, not at all in small sections (up to 9 in. thick). Regarding their use in heavy sections, there are occasions, such as this one, when their use is well-nigh unavoidable.

Scabbing was eliminated to a large degree with faster pouring, with increased nailing of the cope, and by shading the cope with internal chills against the intense heat of rising metal.

(To be continued.)

Distribution of Steel

FEATURES OF REVISED SCHEME

When the first edition of the booklet entitled "Distribution of Steel Supplies" was introduced five months ago, it was stated that there would necessarily be a trial period, and the experience gained during that time would enable adjustments to be made for the more practical working of the scheme. These, together with provisions to deal with certain developments that have taken place, have now been incorporated in a revised simplified edition.

The use of Department symbols, period numbers and Iron and Steel Control licences is retained. Symbols, which can only be authorised by a Government Department, and period numbers, with tonnages, must be quoted by all consumers of steel when placing orders with finished-steel manufacturers. The symbol indicates which Government Department is responsible for an order, and the period number indicates the time during which the steel should be supplied. The Department contract or reference number will, in the revised Scheme, be automatically included in *an authorisation form which will be signed*, on behalf of the Department, by the officer responsible for placing the order. A similar authorisation form will be used by the contractor in dealing with sub-contractors. This is a new feature, and is designed to prevent duplication of the same order as a means to obtain more steel than is actually required.

Iron and Steel Control Licences

When there is no direct authorisation from a Government Department, a licence (which automatically includes a Board of Trade symbol) from the Iron and Steel Control is necessary. This, with the licence number, must then be quoted instead of the Department authorisation referred to above. Licences authorising the purchase of finished steel will be issued by the Iron and Steel Control for home civilian trade, direct export trade and stockholding merchants (or to replenish stock for home civilian trade, and direct export), and for repairs and maintenance in certain cases.

A manufacturer who uses stock for the home civilian trade and for direct export, or a stockholding merchant, cannot replenish stock without an Iron and Steel Control licence. Supplies to stockholding merchants for stock are intended primarily for sale only for essential purposes for home civilian trade, and it is expected that merchants will co-operate in this regard.

Supplies for Building Purposes

Contractors and their suppliers who have obtained authority from a customer to quote a symbol, authorisation number and period number to acquire constructional steel, will note that this authority covers the acquisition only of constructional steel, and not the securing of the steel necessary to carry out the job. Supplies of finished steel for the stock of a structural engineer will be authorised only by Iron and Steel Control licence, and will in general be restricted to a maximum of 50 tons per month. Applications to acquire the steel from mills or a stockholding merchant must be submitted to the Iron and Steel Control on Form S.W. In the case of steelwork other than that for inclusion in a building, the raw material may be obtained from mills on the authority of a symbol, etc., without the necessity of the manufacturer or fabricator obtaining a licence from the Control.

Private enterprise works of building or civil engineering construction, where the estimated cost exceeds £500, require a licence from the Commissioner of Works under the Defence (General) Regulation 56A, and application to use the "O.W." symbol for structural steel or other finished steel should be made to the local licensing officer of the Office of Works by whom the licence was issued.

Home Civilian and Direct Trade

No licence is required to purchase articles wholly or partly made from finished steel, but any manufacturer of such articles for the home civilian trade or direct export trade making a direct purchase of finished steel from a producer must first obtain a licence from the Control.

Applications for licences must be made to the Iron and Steel Control by the person desiring to acquire the finished steel, except where the finished steel is required to fulfil a contract, in which case the main contractor must apply for a licence to cover his own requirements and those of any sub-contractors. Unless this provision is strictly observed, contractors may subsequently find that finished steel required for a particular contract has been authorised in part and refused in part.

In the case of indirect export, as, for example, where steel represents only a portion of the finished product, members of an Export Group should apply to the Group Secretary, who will obtain the necessary authority from the Board of Trade.

Replacement of Steel

A contractor or sub-contractor using finished steel from his own stock to fulfil authorised orders may replenish such stock by quoting Department symbols, etc., on each order. In the case of a relatively small tonnage used to fulfil a large number of orders, it will not be necessary to furnish this detailed information. The contractor must certify that he has obtained the necessary authorities, and, if asked to do so, give details to the Iron and Steel Control. A manufacturer who makes articles for stock may replace the tonnage of finished steel used in articles sold from his stock over a period in cases where all finished steel used in any one quarterly period does not exceed 20 tons in quantity or £250 in value—without any authority, on the manufacturer certifying to his supplier that his purchases in the current quarterly period of the respective categories of finished steel listed in Appendix C of "Distribution of Steel Supplies" will be within the limits set out in the following categories, giving maximum weight in quarterly period, maximum value in quarterly period, and in parentheses (maximum weight per week):—

(1) HEAVY STEEL PRODUCTS.—Billets; medium plates under $\frac{1}{16}$ in. down to and including 3 mm.; rounds, squares and hexagons 3 in. thick and over; flats over 5 in. wide—20 tons, £250. (2) RE-ROLLED PRODUCTS.—Angles and tees 4 united inches and under; channels 3 in. web and under; free-cutting bars; spring steel bars; file steel bars; bright bars; ferro-concrete bars, rivet bolt and nut bars, hoop and strip including cold-rolled steel strip; rounds, squares and hexagons under 3 in. flats 5 in. wide and under; gate channels; sash and casement sections; glazing tees—12 tons, £150. (3) Sheets, coated and uncoated, less than 3 mm. thick including galvanised, lead-coated, R.P.M. and cellactite sheets—12 tons, £250. (4) Tinplates (including tinned sheets)—3 tons 18 cwts. or 39 double boxes, £130 (6 cwts. or 3 double boxes). (5) Terneplates (including terne sheets)—3 tons 18 cwts. or 39 double boxes, £130 (6 cwts. or 3 double boxes). (6) Blackplates—3 tons 5 cwts., £130 (5 cwts.). (7) Silver-finished plates—5 cwts., £130 (5 cwts.). (8) Steel tubes and pipes (including imported hollows)—2 tons, £50. (9) Bolts, nuts, screw studs, washers—26 cwts., £130 (2 cwts.). (10) Rivets—26 cwts., £130 (2 cwts.). (11) Screws—26 cwts., £130 (2 cwts.). (12) Wire rope—6 cwts., £40. (13) Coated or uncoated wire, whether plain or barbed—2 cwts., £2. (14) Any products mentioned above and made of special or alloy steels—12 tons, £150. Finished steel acquired under licence must be used for the purpose specified in the application.

The revised edition of "Distribution of Steel Supplies" describes the scheme in detail. It is divided into six sections:—(*a*) General; (*b*) placing of orders for finished steel; (*c*) contracts placed by or for Government Departments; (*d*) purposes not being Government contracts; (*e*) purposes covered by Iron and Steel Control licences; (*f*) supplies for building purposes.

There are five appendices to the booklet, defining the finished steel products covered; the Departments and relative services brought under the scheme; forms of authorisation; names of local reconstruction panels who are responsible for finished steel supplies for air-raid emergency repairs.

Application for copies of the booklet on "Distribution of Steel Supplies" should be made to the Registry, Iron and Steel Control, Tothill Street, London, S.W.1.

Relation of Defects in Enamel Coatings to Hydrogen in Steel*

By C. A. ZAPFFE and C. E. SIMS

Introduction

In view of recent important metallurgical work on hydrogen in steel, an examination of the literature on enamelling defects indicates a possible correlation between such defects and the presence of hydrogen. The failure to identify hydrogen as a most important source of these defects may be attributed to the ambiguity that has attended the complex behaviour of this gas in steel, but the known ease with which absorbed hydrogen embrittles and ruptures steels and the fact that this gas is apparently as omnipresent in steel as the element carbon, should have attracted more suspicion than has been accorded.

A brief discussion† of the metallurgical aspects of hydrogen in steel is first presented to aid in understanding the experimental work and hypotheses that follow. An exhaustive review of the English literature and the past ten years of the German literature on enamelling defects is included. Over two hundred references are contained in the bibliography, which includes only references on enamelling defects. The many unanswered, and sometimes wrongly answered, questions that stand in this mass of literature are shown to be largely answerable from the standpoint that hydrogen contained in the steel either directly or indirectly causes the particular defect.

It is the purpose of this Paper to discuss the relationship between hydrogen and many of the defects that plague the enameller. It would be wearisome to the reader if, in every section, a paragraph were inserted to say that the particular defect under discussion may be wholly or partly produced by a variety of other factors. Such factors as dust in the shop atmosphere, wrong weight of enamel applied, wrong fineness of grinding, wrong choice of dispersing agents, opacifiers, etc., enter into the production of many defects. In the various cases where hydrogen is shown or suspected to be an agent, it is naturally not necessarily the sole or most important one. It is not the task in hand to deal with all causes of defects or to consider the relative importance of every one of a group of multiple causes. Let this paragraph be understood as applying to all that follows.

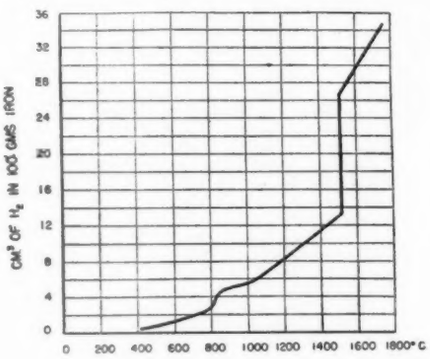

FIG. 1.—VARIATION OF THE (REVERSIBLE) SOLUBILITY WITH TEMPERATURE FOR HYDROGEN IN IRON AT 1 ATMOSPHERE PRESSURE. (SIEVERTS.)

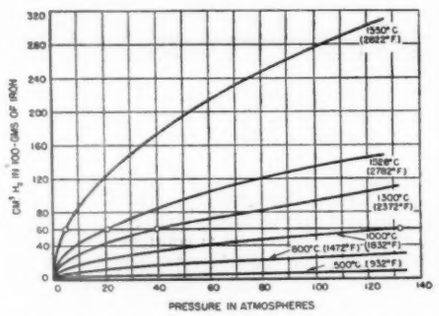

FIG. 2.—RELATION OF THE (REVERSIBLE) SOLUBILITY TO PRESSURE FOR HYDROGEN IN STEEL. (BARDENHEUER AND KELLER.)

THEORETICAL CONSIDERATIONS OF HYDROGEN IN STEEL

"Irreversible" Molecular Occlusion

Perhaps the most remarkable single feature of the steel-hydrogen system is the ability of hydrogen to collect under tremendous pressure within discontinuities in the steel, whether these discontinuities be blowholes, inclusions, macroscopic cracks, and grain boundaries or rifts in the submicroscopic structure. The explanation of the phenomenon lies principally in the two facts that hydrogen dissolves in steel only as the nascent or atomic gas, H (not as the molecular gas, H_2), and that the solubility of the gas decreases several thousandfold from melting temperatures to room temperature.

The variation of solubility with temperature for hydrogen in pure iron is shown in Fig. 1. Below 400 deg. C. the amount of hydrogen in true solution becomes immeasurably small. The solubility varies with the square root of the pressure at constant temperature (Fig. 2), conforming to the mass-action law:—

$$H_2 = 2H$$

$$K_H = \frac{(P_H)^2}{(P_{H_2})}$$

$$P_H = K'_H \cdot (P_{H_2})^{1/2}.$$

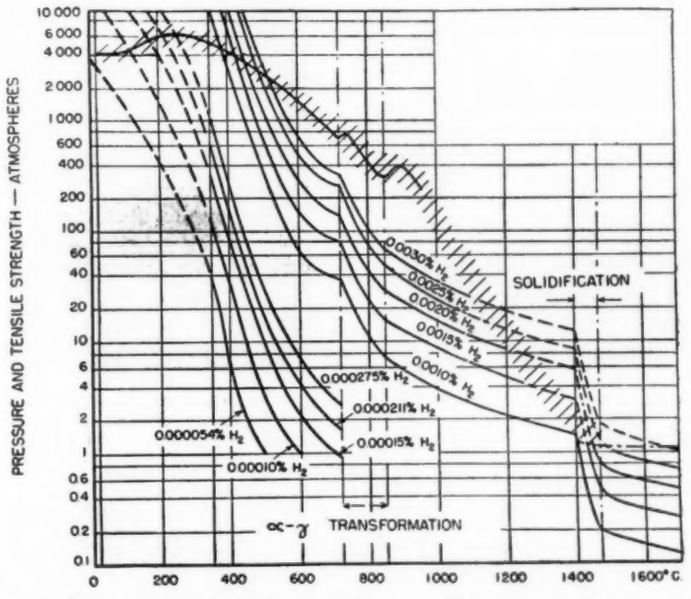

FIG. 3.—THEORETICAL PRESSURES DEVELOPED BY HYDROGEN IN STEEL DURING COOLING. (LUCKEMEYER-HASSE AND SCHENK.) ALL OF THE CURVES REPRESENT PRESSURE DEVELOPED BY HYDROGEN, EXCEPT THE SHADED LINE, WHICH REPRESENTS THE TENSILE STRENGTH OF CAST STEEL.

This relationship proves that the gas dissolves only atomically. Other researches have clearly demonstrated that the atoms are held interstitially in the iron lattice. The imperviousness of steel to molecular hydrogen is demonstrated by the fact that steel tanks are used for containers of hydrogen; and it has been shown experimentally that to force molecular hydrogen through steel requires pressures exceeding the elastic strength of steel.

It is evident that the sharp decrease in solubility that occurs with decreasing temperature (Fig. 1) will cause a high degree of supersaturation to obtain when steel is cooled, even though

* Presented at the Forty-second Annual Meeting, American Ceramic Society, Toronto, Canada, April 9, 1940(Enamel Division), and reproduced by kind permission of the Council of the Society. The authors are Research Associate and Supervising Metallurgist respectively, Battelle Memorial Institute, Columbus, Ohio.

† For a more detailed discussion of the fundamental metallurgical aspects of hydrogen in steel, see "Flakes, Shatter Cracks, and Hydrogen in Steel," by the present authors, published in "Metals and Alloys," **11** [5], 145–51 (1940). All statements of a metallurgical nature made in the present Paper have been excerpted from the former, and their authorities may be found in that Paper.

the solution at the elevated temperature was dilute. To hold the excess atomic gas in solution in the metal, an equal pressure of atomic hydrogen is necessary outside the metal lattice. As the decrease in solubility is about one thousandfold from the firing temperature of porcelain enamel to room temperature, roughly one thousandfold increase in the partial pressure of atomic hydrogen would be required to prevent precipitation of hydrogen in a cold steel that had been previously saturated at the firing temperature. At ordinary temperatures, however, hydrogen is so extremely stable in the molecular state that unattainable total pressures of the gas would be necessary to provide this required partial pressure of atomic hydrogen. In addition, increased pressure favours still further the formation of molecular hydrogen as there is a volume change.

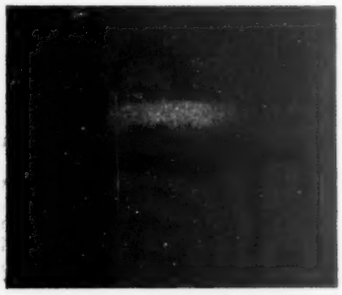

Fig. 4.—Blister on Unpickled Steel Sheet caused by Hydrogen inherited from the Melt.

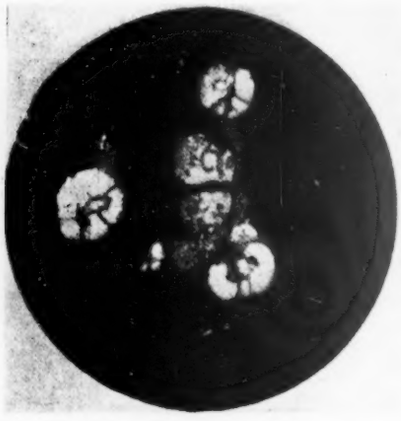

Fig. 5.—Flakes or "Fisheyes" in Weld Metal caused by Hydrogen trapped during Welding (Tensile Specimen).

Dissolved hydrogen, therefore, will diffuse out of the metallic lattice almost without hindrance; and, when this escape takes place at an *internal* surface, the escaping atoms will recombine to form molecular hydrogen in the discontinuity until the equilibrium pressure is attained or the metal ruptures. Such "trapping" is especially favoured by the fact that diffusion is extremely slow at ordinary temperatures and escape at external surfaces scarcely affects the concentration of gas at internal surfaces.

Simple calculations of these potential internal pressures, using the solubility values from the curve in Fig. 1, result in the curves shown in Fig. 3. It is seen that considerably less than 0.001 weight per cent. of hydrogen in steel can produce pressures at ordinary temperatures that exceed the strength of the steel. Accordingly, it has been amply demonstrated that hydrogen can rupture the strongest steel.

Appreciating the comparative insignificance of the pressure that would be required to raise a blister in fused enamel, it is clear that the most minute trace of hydrogen in steel should be regarded with suspicion; and although special treatments may remove a large portion of the gas, their results should never be regarded as being absolute.

Sources of Hydrogen in Steel

Referring again to Fig. 1, it is evident that the commonest source of hydrogen is probably in the melting procedure, as very dilute solutions in liquid steel may still provide supersaturated cold stock owing to the great change in solubility with temperature. Sources of hydrogen in the steelmaking process are numerous, such as combustion gases, humidity of the air, moisture in the raw materials, and water combined chemically with the charge. For example, the addition of just 1 per cent. of rust to a bath of steel provides about 20 volumes of hydrogen (S.T.P.) per volume of steel, which is approximately the saturation value for liquid steel under one atmosphere pressure of pure hydrogen. Moisture readily dissociates in contact with iron at elevated temperatures and provides two atoms of hydrogen for every atom of oxygen that combines with the iron. The significance of the moisture content of the air is illustrated in recent work with an "air-conditioned" blast furnace, wherein it was observed that water carried into the furnace by the blast varied from 72 galls. per hr. in winter to 1,000 galls. per hr. in summer. It is fairly well accepted by metallurgists that steel made in damp weather tends more to hydrogen defects than steel made in dry weather, and it is interesting to note in the literature on enamel defects that a few investigators have suspected a similar relationship in regard to the reboiling of enamelling stock. Many enamellers have suspected the steelmaking process though they have not identified the mechanism.

Examples of metallurgical defects notably caused by hydrogen remaining in steel from the melt are the "flakes" that occur in forgings and the "shatter cracks" that occur in rail steels. Fig. 4 shows another common defect, a large blister on unpickled steel sheet caused by hydrogen inherited from the melt.

If finished steel stock does not contain an important quantity of hydrogen, whether for reasons of good melting practice or favourable treatments, hydrogen may enter the steel in many ways subsequent to finishing. Welding introduces a great deal of hydrogen to steel, for hydrogen is copiously contained in cellulose coverings, in gas-weld atmospheres, and in attendant moisture. Fig. 5 shows an outstanding instance of "flakes," or "fisheyes," caused by hydrogen in weld metal. The cavities that trapped the gas are readily visible; and the radial cracks, extending from the cavities into the steel and the surrounding embrittled zone, reveal the tremendous volume and pressure of the gas that had been occluded there. Enamellers have had a great deal of trouble applying coatings to weld metal.

At ordinary temperatures, one of the most common reactions that supplies hydrogen to steel is rusting, whereas the greatest quantities, and the most rapid absorption of the gas, are obtained from pickling or cathodic electrolysis. Any action that provides nascent hydrogen at the surface of the steel will cause absorption of this hydrogen, and at ordinary temperatures steel shows a remarkable ability to occlude the gas, probably molecularly in internal, submicroscopic rifts. Cold-working the steel causes these rifts to increase in size and number, with the result that a specimen may take up hydrogen in quantities thousands of times greater than the true solubility. It is interesting to note that in enamelling, if the steel is scratched, blisters will appear over the scratch. At enamel-firing temperatures, dissociation of chemically bound moisture is an obvious source of hydrogen.

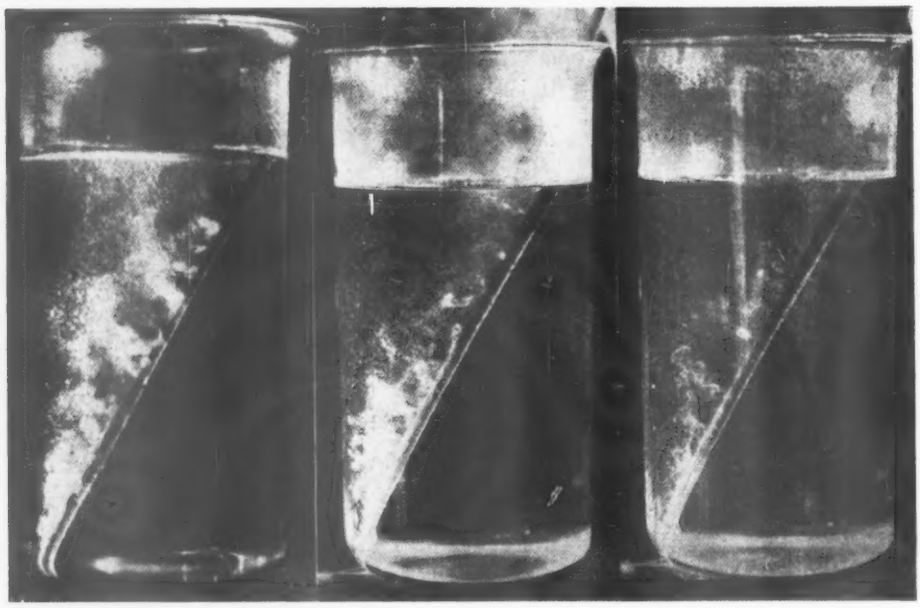

Fig. 6.—Hydrogen evolving from ¼-in. Steel Wire placed in Previously-Boiled Water at 95 deg. C. after 10 mins. Pickling in Warm Dilute Sulphuric Acid. After Immersing: (Left) 30 secs.; (Middle) 5 mins.; (Right) 10 mins.

When the gas precipitates molecularly in the minute rifts just mentioned, very little precipitation need occur to provide a high aerostatic pressure, and the great dispersion of these rifts causes the cumulative effect to exhibit itself as general embrittlement of the steel. When precipitation occurs at larger loci, for example, at inclusions, cavities, and grain boundaries, the pressure does not increase so readily and no noticeable deterioration need occur. The volume of the occluded gas then becomes an important factor, especially in enamelling practice, because at firing temperatures molecular hydrogen dissociates quite rapidly in the presence of iron and is then free to re-diffuse into the steel. The consideration of this trapping, storing, and re-diffusion of hydrogen at enamel-firing temperatures provides the basis for this Paper.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

Ageing and low-temperature annealing are popularly supposed to drive hydrogen out of steel. So the treatment does, but *only* that hydrogen which is in true, reversible solution or that which is in exceedingly small rifts where the ratio of surface to volume is very large. Otherwise it may be generally stated that hydrogen occluded in steel will remain in the steel until heated to about 800 deg. C., where dissociation in the presence of iron first becomes fairly rapid. At this temperature, however, a strong increase in the solubility occurs (Fig. 1), and the hydrogen liberated from the cavity or inclusion is no longer so pressed to leave the steel but will proceed instead to saturate the lattice surrounding the discontinuity. The complications that may result should now be evident. For example, the transformation from alpha to gamma, and concomitantly the solubility increase, in ordinary enamelling stock lies well above the temperature at which rapid diffusion of molecular hydrogen occurs. As the specimen heats during firing, some dissociation will occur before the solubility has markedly increased, and the released hydrogen will diffuse rapidly out of the cavity and seek the surfaces of the steel, there to collect perhaps under the freshly fused enamel and raise first a wrinkle, from the general effusion, and then a blister, for reasons of surface tension. The lag in heating the steel aids this effect. But, as the specimen comes to the temperature of the furnace, the solubility of hydrogen in steel so markedly increases that the gas is able to redissolve, and the blister disappears. When cooled, the specimen will contain a region supersaturated with hydrogen, part of which will find its way again to the cavity to be available for "reboiling"

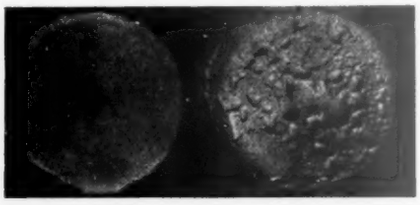

Fig. 7 (Left).—Glyptal Coating on Iron Crucible Bottom, showing Blisters caused by Hydrogen which Diffused through the Crucible.

Fig. 8 (Right).—Same Crucible Coated with Ordinary White Paint.

and the other part will seek the surface of the piece, perhaps to cause "fishscaling" and "chipping." Oddly, the hydrogen theory was discarded by many enamellers because it did not account for the cyclic nature of reboiling.

The difference between the responses of dissolved and of occluded hydrogen to annealing at low temperatures has apparently confused the issue of hydrogen in enamelling defects. Most enamel plants have modified their procedure for preparing stock for enamelling so that hydrogen absorbed during the pickling process is eliminated, but the methods of elimination have been based on the supposition that all hydrogen in steel is reversibly dissolved and is rapidly removed by low-temperature annealing.

There are other complicating reactions that retain hydrogen in steel in addition to the formation of molecular hydrogen at discontinuities, for hydrogen is strongly attracted by many elements other than iron, especially when the hydrogen is atomic. When impurities in steel are segregated as inclusions, the atomic hydrogen at the moment of precipitation in the inclusion may react with the material of the inclusion to form products more (or less) stable than molecular hydrogen, and temperature functions will be distorted according to the stability of the compound in contact with iron.

On the other hand, the impurity, such as carbon, may be molecularly dispersed. It is known that cementite is unstable and that the carbon-hydrogen bond is very strong. Experiment corroborates theory to show that hydrogen is retained by carbon in steel probably in the form of a quasi-methane structure. The formation of methane from atomic hydrogen ostensibly entails a fourfold volume decrease and would thereby effectively decrease the precipitation pressure. As carbon-hydrogen structures decompose quite completely at about 600 deg. C., hydrogen may be liberated in a considerable fraction at this temperature. Whether or not the hydrogen then leaves the steel depends of course on the nature of the contact of atom to metal lattice at the moment of decomposition. If the contact is not good, molecular hydrogen will form.

From this brief discussion it is evident that, although the hydrogen-iron system is amenable to prescribed treatments, the hydrogen-steel system is more complex and will therefore not yield to treatments designed to remove hydrogen from iron except in a rough, qualitative way. It can only be said, summarily, that hydrogen in steel will behave with changing temperature about as follows:—

(1) At room temperature, the fraction of hydrogen that is in actual solution or is precipitated in submicroscopic rifts will slowly diffuse out of the specimen, several days being required to effect a significant change except in very thin specimens. The rolling or banded structure in sheet steel further prohibits this effusion, as will be shown.

(2) At temperatures of 100 to 300 deg. C., roughly, the same effusion in (1) will occur in a matter of minutes, as the rate of diffusion of hydrogen in iron increases logarithmically and very rapidly with increasing temperature. All other fractions of hydrogen remain quite unaffected.

(3) At temperatures above 400 deg. C., quasi-methane structures will break down to free hydrogen either in a diffusible or an indiffusible state, depending on the nature of the segregation.

(4) At approximately 800 deg. C., trapped molecular hydrogen will dissociate and re-diffuse into the iron.

(5) At higher temperatures, hydrogen compounds that are more stable in contact with iron than molecular hydrogen will dissociate.

The story of hydrogen in enamelling stock may also be briefly summarised as follows. Hydrogen liberated from occlusion during firing will first spread through the steel surrounding the discontinuity. A portion of the gas may find its way to the surface of the piece to cause blistering depending on the location of the discontinuity. If the steel comes to temperature before the hydrogen reaches the surface or if the re-solution is delayed for some chemical reason until the steel has transformed to face-centred-cubic gamma, a more active solvent, the freed hydrogen may merely dissolve in the metal lattice and need not leave the specimen in appreciable quantities until the temperature is lowered and the decreased solubility again forces the gas out of the lattice. A portion will then find its way out of the steel and another portion will return to the cavity. This fraction of occluded hydrogen thus serves to provide recurrent local supersaturation. In the fabrication of steel products, such recurrence is evidenced in the occasional reappearance of "flaking" and other hydrogen-caused defects; in enamelling, the analogous phenomenon is termed "reboiling." In every case, of course, successive appearances of the defect are progressively mitigated because the hydrogen gradually disperses and ultimately leaves the steel.

When the enamel has hardened, the precipitation at the metal-enamel interface of hydrogen released into the steel at firing temperatures creates local pressures that lead to "fishscaling" by the same means that blisters were raised at higher temperatures.

Experimental Observations

The following experiments illustrate the preceding arguments. The effects of hydrogen inherited from the steelmaking process and from welding have already been illustrated in Figs. 4 and 5. The magnitude of hydrogen absorption from pickling, however, is so great that in comparison other sources are almost unimportant. Fig. 6 shows the surprising quantity of hydrogen that a small steel wire will absorb during the ordinary pickling procedure used in preparing steel for enamelling. The rod has been pickled only ten minutes in dilute sulphuric acid, rinsed, and immersed in previously-boiled water heated to 95 deg. C., to accelerate diffusion. Such an effusion, continuing as shown for more than ten minutes, is, to say the least, remarkable. An attempt to apply a coating of Glyptal lacquer to such a specimen naturally failed.

Fig. 7 shows the bottom of an iron crucible that has been coated with Glyptal. Dilute sulphuric acid inside the crucible generated hydrogen which diffused through the iron, formed molecular hydrogen underneath the lacquer, and formed blisters (note the size of the blisters). The strong effect of permeability of the coating

Fig. 9.—Bottom of Enamelled Pan showing Enamel Exploded Away by Hydrogen which had Diffused through Pan. (Note Litmus Paper.)

on regulating the severity of blistering is evident in the comparison of Fig. 8 with Fig. 7. Fig. 8 shows the same crucible bottom coated with a viscous white paint, and it is seen that the blistering is much more acute. The analogy to vitreous enamel coatings is important.

When the coating is rigid and hard, the blistering action naturally becomes a rupturing action, identified in enamelling practice as "fishscaling" and perhaps "chipping," "pop-offs," etc. An unusually severe instance of this type, artificially produced, is shown in Fig. 9. Dilute sulphuric acid inside a porcelain-enamelled pan provided hydrogen that penetrated into the metal underlayer in much the same manner that internal reactions of steel at elevated temperatures with hydrogen in discontinuities produce supersaturation according to principles already discussed. The inside of the pan was scraped bare of enamel to permit acid reaction with the iron. The hydrogen diffused through the pan and recombined at the submicroscopic metal-enamel interface to form pressures of molecular hydrogen that literally exploded the enamel from the pan and threw pieces as far as six feet. The litmus paper (Fig. 9) was used to show that no trace of acid had seeped through the metal at any point and that the pressure was generated only by hydrogen that had diffused through the iron in the manner already discussed.

(To be continued.)

FRY'S SOLDER INFORMATION

Soft Solders for higher temperatures

Metals and alloys inevitably lose much of their strength at temperatures approaching their melting point. For normal soldering work, where the joint is not highly stressed, tin-lead alloys are adequate for units containing boiling water. Where higher working temperatures are in use, as for instance glycol-filled radiators for aeronautical purposes, and for joints which may be highly stressed, such as the end connections of rotor and armature windings, other alloys must be used, having higher melting points and consequently better strength at working temperatures exceeding 100° C. There are two possible alloys which may be used: tin-antimony and lead-silver. Fry's have carried out a good deal of research on solder of these types and now market a lead-free tin-antimony solder under the mark H.T.3 and two lead-silver solders, L.S.1 and L.S.2. At room temperatures the normal tin-lead solder is harder and, therefore, stronger than the special solders; at 100 C. there is little difference between the four solders; at 150° C. the special solders are stronger than tin-lead, and at 180° C., where tin-lead has lost all strength, the special types still retain some strength.

ALLOY	MELTING POINTS		BRINELL HARDNESS (10 mm. ball 125 Kg. load 30 secs.)				
	Solidus	Liquidus	15° C.	60° C.	100° C.	150° C.	180° C.
Tin-lead eutectic solder, 63% Tin	183° C.	183° C.	13.8	8.7	5.3	2.7	Nil
Fry's H.T.3 ...	236° C.	243° C.	10.3	7.25	5.45	3.65	3.0
Fry's L.S.1 ...	305° C.	310° C.	7.1	6.55	5.35	3.75	3.0
Fry's L.S.2 ...	305° C.	305° C.	7.1	6.85	4.95	3.65	3.0

H.T.3 is recommended for all except special work as its high tin content makes it particularly easy to handle. It "tins" rapidly and has a good fluidity. The lead-silver alloys are for use where the joint is constantly subjected to high temperatures which may cause compound growth and consequent embrittlement.

Further particulars are given in technical leaflet No. 5A which will be sent on application.

Technical leaflets are available in connection with all types of Solders and Soldering fluxes.

FRY'S METAL FOUNDRIES LTD.

TANDEM WORKS, MERTON ABBEY, LONDON, S.W.19.

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The Week's News in Brief

Trade Talk

THE FERRO ENAMEL CORPORATION, of Cleveland, Ohio, U.S.A., through its subsidiary, the Liquid Plastic Corporation, has entered the synthetic finish field.

HENRY DISSTON & Sons, Inc., of Philadelphia, has celebrated the centenary of its establishment by Henry Disston, an Englishman. The firm is amongst the most prominent of American saw manufacturers and has melted its own steel since 1855.

IN the half-yearly report of the Iron Founding Workers' Association, Mr. Hugh Murdoch (general secretary), Falkirk, states that the membership has decreased by 370, the total now being 10,747. This decrease is accounted for by a large number having found work outside of the trade.

INVOLVING an expenditure of between £40,000 and £50,000, Newbold General Refractories, Limited, is remodelling and installing new plant at its Waratah (New South Wales) works. Earlier in the year the company announced a new issue of shares. The money was raised to finance the installation of the new plant, the company having acquired the Australian rights to manufacture special refractories, formerly supplied by General Refractories Company of America.

ARRANGEMENTS have now been made for the training of instructors, who will conduct local courses for factory watchers in each civil region. The arrangement for these courses will be made locally, and employers are requested not to apply for their watchers to be trained unless and until applications are invited. No time will be lost in beginning the courses. Meanwhile, schemes for working after the sirens sound should be carried forward with the best watchers available.

EMPLOYEES of Colvilles, Limited, of Glasgow and Lanarkshire, have started a fund to provide supplementary allowances for comrades in the Services. They contribute 1d. to 3d. in the £ each week from their wages, and the company adds 25 per cent. to the total. The fund amounts to nearly £20,000, and supplementary allowances range from 5s. a week for unmarried men to 10s. for those who are married. Arrangements are being made whereby surplus funds will be available after the war to make provision for casualties.

AS a result of the immense war effort being made by Canada, the iron and steel production figures for July again showed an important increase to establish new monthly records. Pig-iron output was 95,924 tons, against 88,656 tons in June last and 59,587 tons in July, 1939, while the output of steel ingots was 169,577 tons, against 166,213 tons and 111,149 tons respectively. Steel output in the seven months was 1,127,823 tons, as compared with 691,290 tons in the parallel period of last year. Current steel production is close to present day capacity, but steel companies have in hand important extensions to plant, the majority of which will be completed towards the end of this year and the rest early in 1941. Although steel-making capacity will continue to show a steady rise for some time, the pig-iron industry has not made corresponding arrangements to increase the ten blast furnaces at present erected in Canada.

THE Institute of Scrap Iron and Steel, Inc., New York, analysing the sources from which scrap is drawn in the United States, computes that domestic consumption of scrap in 1939 was 32,400,000 tons and exports 3,500,000 tons, making a gross total of 35,900,000 tons. Replacement of rails and the dismantling of old equipment by the railway companies provided 3,500,000 tons of scrap, while the production of new scrap in metal-working plants was 3,250,000 tons. Old cars scrapped accounted for 2,675,000 tons, but the greater part was works scrap produced and remelted by the steel and foundry industry in normal manufacturing operations. An unaccounted tonnage of 7,700,000 is credited by the Institute to the collections by peddlers, the dismantling of railroad branch lines, the demolition of buildings and general wear and tear on commodities made from iron and steel. The total value of the scrap produced in the United States during 1939 was over $600,000,000.

Obituary

IT IS WITH very deep regret that we announce the death of Sir Robert A. Hadfield, Bt., F.R.S., D.Sc., D.Met., at the age of 82, in a London nursing home. For more than a year he had been unable to participate in public life. The son of a steel manufacturer, Hadfield received his early training at the Collegiate School, Sheffield, which then occupied part of the site of the Applied Science Department of Sheffield University. He showed little evidence in early years of his brilliant future, and it was perhaps for this reason that he was sent to the works on leaving school. Here he immediately interested himself in the improvement of steel by alloying, which culminated in his discovery of manganese steel. His second most famous invention was that of high-silicon steel, which is universally used in the construction of electric transformers. His business—Hadfields, Limited—materially benefited from his inventions, but Sir Robert once confessed to the writer that this was due mainly to his ability to surround himself with men of outstanding quality. Such progress was registered that, during the last war, he could claim that his steel foundry was the largest in the world. In later life he took very considerable interest in this department, and would often send for our Editor to discuss with him some of the latest developments. He had a profound regard for the working moulder, as indeed he had for all skilled workmen. He showed this in a very practical manner by being the first manufacturer to accord an 8-hour working day to his men. It was his ambition to be first to grant holidays with pay, but at this time, round about 1929 or 1930, the steel industry, and particularly the steel-foundry section, was in the depths of a trade depression. Hadfield took a greater interest in the work of the Institute of the British Foundrymen (of which he was its first honorary member) than most of its members realised. He insisted on the regular and punctual receipt of all its publications, and often expressed his desire to participate more fully in its work, but his public commitments had by then left him but little time for additional duties. What leisure time he could spare he devoted to fishing or golf, and, moreover, he did much to popularise the latter amongst his colleagues and gave a silver cup to the old Engineers' Club. Since the last war, and until recently, he worked mainly from his home in Carlton House Terrace, where he maintained a large secretariat. The production of a new book, of which he wrote several, or of a Paper for presentation to one of the learned societies, or his annual address to the shareholders, was invariably carried through with meticulous care. Draft after draft would be prepared, amended or rejected, until, perhaps after working far into the night, perfection would be attained. Whether or not Hadfield was too punctilious, it is a fact that but very rarely have his pronouncements had to be modified. Other biographers will detail his mainly well-earned academic honours, of which he was justly proud, but the two which afforded him the greatest satisfaction were the receipt of the Bessemer Medal of the Iron and Steel Institute and his election to a Fellowship of the Royal Society. His benefactions were munificent, and Sheffield University (in particular the Metallurgical Department) owes much not only to his donations, but also to his personal interest. In conjunction with Lady Hadfield, he maintained a military hospital at Wimereux during the whole of the last war. Though the name of Hadfield will, together with those of Bessemer, Siemens and Thomas, be familiar to generations of students yet unborn, to those who knew him personally his passing means the loss of a gentleman of infinite charm.

Company Meeting

Qualcast, Limited

Presiding at the annual meeting of Qualcast, Limited, held at Derby last week, MR. J. E. V. JOBSON (chairman and managing director) said that the trading profit for the year, at £99,663, was again a record. Both their English factories were fully engaged upon national work, and their Australian plant was at the disposal of the authorities.

Contracts Open

Birmingham, October 7—Supply, laying underground, etc., of cast-iron water pipework (8 in. to 20 in. dia.), for the Electric Supply Department. Mr. F. Forrest, chief engineer, 14, Dale End, Birmingham, 4. (Fee £2, returnable.)

Johannesburg, November 4—10-ton steam travelling crane, for the South African Railways and Harbours. (D.O.T. reference: T. 21793/40.)

Personal

MR. T. K. BRIGGS, of Middlesbrough, who has been appointed Chief Labour Supply Officer and area chairman of the Labour Supply Board, has resigned from the secretaryship of the Tees Development Board, and has been granted leave of absence from the secretaryship of the Teesside Chamber of Commerce.

Will

PRINCE-SMITH, SIR PRINCE, of Keighley, head of Prince-Smith & Stells, Limited, machinery manufacturers and ironfounders £173,662

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Applin & Wilson, Limited, Abbey Estate, Mount Pleasant, Wembley—Capital, £480. Metal refiners. Directors: C. R. Wilson and E. Platschek.

Mesh-Steel, Limited, The Cedars, Cowley, Uxbridge, Middlesex—Capital, £1,000. Directors: E. A. Bamberger, F. W. E. Stapenhorst, and K. J. Sommerfeld.

Chemical Analysis of Alloy Cast Iron

(*Continued from page* 222)

In conclusion, the author wishes to express his thanks to the Director and Council of the British Cast Iron Research Association for permission to publish these researches.

Chemical analysis forms one of the most important means whereby information is obtained about the ferrous metals and precise recorded methods do much to minimise differences between laboratories. To assist in establishing recommended procedures, the first report on methods was issued by the B.C.I.R.A. in 1928 and was issued for general use by all interested in 1933 (Special Publication No. 1, Recommended Methods for the Sampling and Analysis of Cast Ferrous Metals and Alloys). This is now out of print, and the above Paper shows that in many respects it has to be brought up to date. It is hoped to accomplish this in spite of the preoccupations arising from the war, during the present year, and this new and revised edition will include the substance of research reports mentioned in items 1, 2, 5, 7, 11 and 13 of the bibliography and hitherto only available to members of the Association, with the exception of items 1 and 2.

Forthcoming Events

OCTOBER 10.

Institute of Metals (London Section):—Chairman's address, by J. Cartland, at Caxton Hall, Westminster, London, S.W.1, at 7 p.m.

OCTOBER 12.

Manchester Association of Engineers:—Presidential address by A. C. Dean, and presentation of Constantine and Butterworth awards, at Engineers' Club, Albert Square, Manchester, at 2.30 p.m.

OCTOBER 16.

Manchester Metallurgical Society:—Joint meeting with Institute of Metals. "Intergranular Corrosion," Paper by Dr. C. H. Desch, F.R.S., at Engineers' Club, Albert Square, Manchester, at 6.30 p.m.

Institute of British Foundrymen

OCTOBER 5.

Lancashire Branch:—"Chromium Heat-Resisting Cast Iron," Paper by R. C. Tucker, at Engineers' Club, Manchester, at 3 p.m.

REFRACTORIES ON PARADE

THE TECHNICAL KNOWLEDGE GAINED FROM RESEARCH IS AVAILABLE TO ALL USERS OF SANDS AND REFRACTORIES FOR THE FOUNDRY

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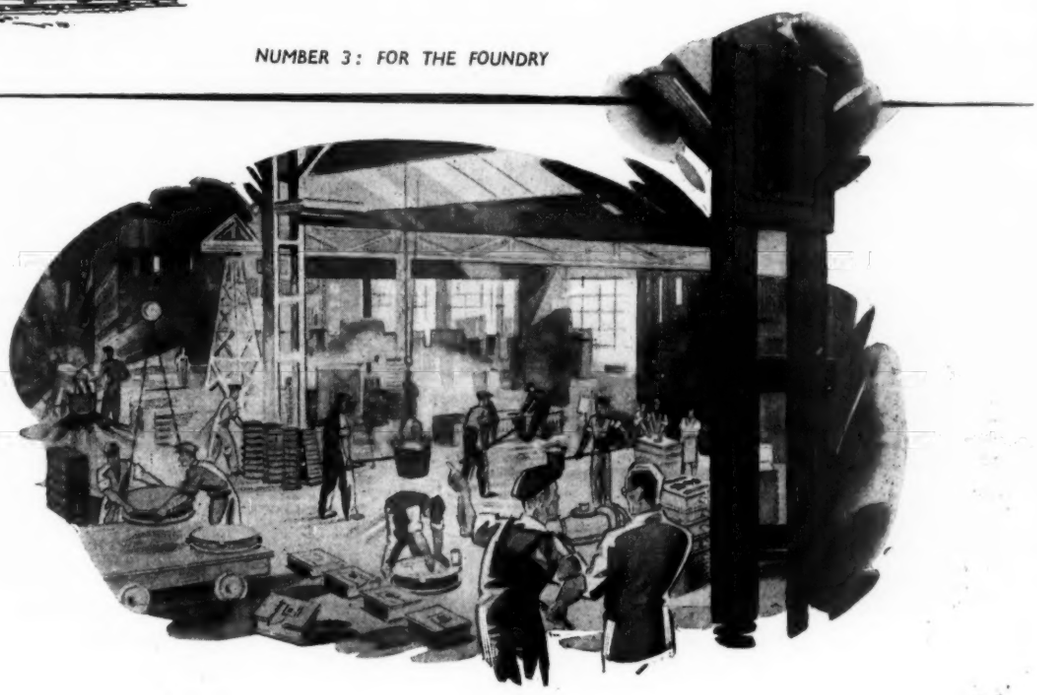

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Raw Material Markets

The Iron and Steel Control have already granted a considerable number of licences to consumers for the purchase of pig-iron up to the end of the year, and furnaces have recently received orders from users anxious to cover their requirements over this period. It seems that priority consumers will continue to have their needs met in full, but other buyers are unlikely to have more than a proportion of their inquiries satisfied, owing to the heavy demands made upon production by works engaged on Government contracts. Certain priority consumers continue to experience a little difficulty at times in acquiring specified grades of iron, but this may generally be overcome by rearranging mixtures so as to utilise the descriptions of iron most readily available.

Pig-Iron

MIDDLESBROUGH—There is hope of a resumption of the production of Cleveland foundry iron in the near future, but output will be on a small scale during the remainder of the year if it is possible to bring any furnaces on to the manufacture of this type of iron, as the greatest need in this area continues to be for iron for the steelworks. Larger deliveries of scrap have relieved the pressure on basic iron to some extent, and one or two furnaces may be able to restart production of Cleveland foundry iron as a result. Consumers, meanwhile, continue to obtain their requirements from the Midlands, and deliveries from this source are quite satisfactory. At the same time, distribution is carefully regulated, and only immediate needs are covered. Demand for East Coast hematite is maintained at a high level, and makers are fully occupied in dealing with current specifications, which account for the total production. Additional imports of hematite, which, it is understood, are being negotiated, will be of considerable assistance. Moderate quantities of local iron continue to be railed to consumers in Sheffield and the Midlands.

LANCASHIRE—Good tonnages of foundry iron are being taken up by users in this area, and satisfactory deliveries are being received from Midlands producers. Chief activity centres in the speciality and general engineers, most of whom have contracts in hand placed by Government departments. There is also a moderate demand from jobbing foundries, but the position of the light-castings trade is still weak and short time is unavoidable at most works. Hematite is in keen demand, but supplies are restricted. Scottish foundry numbers are moving here on a small scale, while only a moderate trade is reported in forge iron.

MIDLANDS—Ironmakers are busy dealing with users' orders for the fourth quarter of the year, as many licences have been issued for this period, and consumers are eager to place their orders without delay. Especially has this been the case in respect of heavy engineering concerns and machine-tool makers, which are big consumers of hematite and low-phosphorus iron, and there has lately been some difficulty in meeting all demands for these grades. Some consumers have incorporated high-phosphorus iron into their mixtures, but this is only possible in certain instances, and other users are compelled to rely on supplies of low-phosphorus iron and hematite produced from imported ores. The Control authorities have the matter well in hand, however, and better supplies may be expected to be forthcoming in the near future, as imports are arriving more freely. The light-castings manufacturers are the chief users of high-phosphorus iron, but trade in this section continues to be only moderate, with the exception of those works which have been able to adapt their plant to cope with Government orders. No changes in prices have yet been announced, and much depends upon the decision of the Railway Rates Tribunal in connection with the recent inquiry.

SCOTLAND—Trade in the Falkirk district remains patchy; some light-castings concerns are quite well placed for orders, while others experience rather quiet conditions, and short time is still prevalent. Most other iron consumers in Scotland, however, are well situated, and consumption is heavy. There is a vast amount of Government work in hand, and replacement orders are freely available to take the place of completed contracts. Steelmaking irons are in great request, and it is necessary to supplement home outputs with Indian and American material.

Coke

Active conditions continue to prevail in the foundry-coke trade, despite the loss of much normal export business. Home users have this year been intent on accumulating large stocks, and most of the bigger buyers have about completed their programme, although they are continuing to make purchases on account of current requirements, so that their reserves shall remain intact. Ovens are able to make adequate deliveries, and the state of the trade is thus very satisfactory. For delivery to Birmingham and Black Country stations, the price of Durham best foundry coke is 55s. 6d. per ton, but all forward business is transacted subject to a rise-and-fall clause, as the Control authorities reserve the right to adjust quotations without notice.

Steel

The call for all classes of steel is unceasing, and works are being called upon to deliver far greater tonnages than ever before. That they are able to meet the increasing requirements of the defence programme reflects considerable credit upon the way in which they have dealt with the war situation from the start. Priority consumers are getting adequate supplies, but other buyers are naturally receiving less than their demands, while export business cannot be attended to in the manner which steelmakers would wish. Producers are obtaining fuller quantities of raw materials, especially scrap, and the position in this respect continues to improve. Imports of semis from abroad have been particularly heavy.

Scrap

The decision of the Minister of Supply to undertake a national survey of the nation's resources in scrap metal has been welcomed in all quarters, but the steel trade is more particularly interested. Deliveries of scrap have improved beyond all expectations during the past few months, and consumers are now able to secure all that they require. The national survey will, however, provide evidence of the position over a long period, and as the Government intends to plan for a long war, the information will be of considerable assistance. Many consuming works are now stopping further deliveries, owing to congestion at their yards. Stocks have been accumulated, and at many works have attained extensive proportions. Every precaution is being taken to assure continuous deliveries throughout the winter, and it is understood that inquiries are at present circulating in the United States for the shipment of about 150,000 tons of scrap to the United Kingdom.

Metals

According to a New York report, Patino Mines and Enterprises Consolidated, which owns tin mines in Bolivia, has announced the approval of plans to construct a tin smelter in the United States in furtherance of the defence programme. It is expected that construction will begin as soon as the National Defence Commission gives its approval. It is aimed to have an annual capacity of approximately 30,000 tons, and it is believed that the cost will be approximately £10 per ton. It would seem likely that the establishment of the smelter is purely a wartime measure and that the plant will be abandoned at the cessation of hostilities. The arrival at Washington last week of Senor Carlos Aramayo, a leading Bolivian tin magnate, aroused keen interest in international tin circles. Senor Aramayo was understood to be discussing with Mr. Sumner Welles, U.S. Under-Secretary of State, the possibility of installing tin smelters in the United States, while he was also expected to meet interested American authorities and members of the National Defence Commission. There is much sympathy among American tin consumers with proposals for the smelting of Bolivian ores in the United States, as a safeguard for future supplies. The recent wide disparity between London and New York tin prices strengthened Bolivian support for the establishment of a tin smelting industry in the U.S.A., but there has since been a remarkable recovery in prices here.

Nothing further is known of any Government plan for the storage of tin in this country on similar lines to the scheme at present operating for rubber, and it is unlikely that such a plan will be evolved in the near future, although it is believed that the authorities are not unmindful of the proposals which have been put forward. It is felt that, if a proper balance can be maintained between stocks here, exports to the United States and elsewhere, and consumption in this country, the result will be the same as if the United Kingdom authorities were actually to buy and store the metal. Although details are not made public, it is generally believed that the Government has an agreement with smelters here whereby it can obtain, at short notice, large supplies of the metal.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £257 to £258; Friday, £259 10s. to £260 10s.; Monday, £257 10s. to £258; Tuesday, £256 to £257; Wednesday, £255 to £256.

Three Months—Thursday, £260 to £260 5s.; Friday, £262 10s. to £263; Monday, £261 to £261 10s.; Tuesday, £260 to £260 5s.; Wednesday, £259 to £259 10s.

Producers in the United States have made a general increase in the price of copper of ¼ cent to 12 cents, delivered Connecticut Valley. This is not at all surprising in view of the fact that producers have been deluged with orders of late. The American defence programme, of course, is calling for rapidly increasing supplies, while United Kingdom requirements are substantial. Details of copper exports from the U.S.A. in August, which totalled 51,680 long tons, make interesting reading and reveal that of this total Japan took 29,269 tons, against 3,136 tons in the previous month, Russia 13,331 (850) tons and Great Britain 7,681 (18,854) tons. It will thus be seen that shipments during the month to Japan and the Soviet Union were greatly increased, while despatches to the United Kingdom fell away. It should be borne in mind, however, that deliveries to Great Britain fluctuate appreciably from month to month and depend on American imports of Rhodesian blister copper for refinement. Comparison of the August figure with that of the succeeding month may also be misleading, as it is believed that in July Britain received copper actually produced in America, an order which, it is understood, was not repeated in August. The freer shipments to Japan and the U.S.S.R. are interesting. The latter country has lately been favoured with the release of many more ships laden with copper from the United States, and considerable supplies are believed to have been transported via Vladivostok. It is not felt that Japan is taking unduly heavy tonnages of American metal, and it is significant that the U.S. export price has not been raised further of late in spite of the heavy domestic trade.

Adequate supplies of both spelter and lead continue to be available to meet the requirements of the war industries, but there is not much zinc to spare for non-essential users. The lead position, however, permits a fair amount of business to be done with home industrial concerns and also foreign buyers.

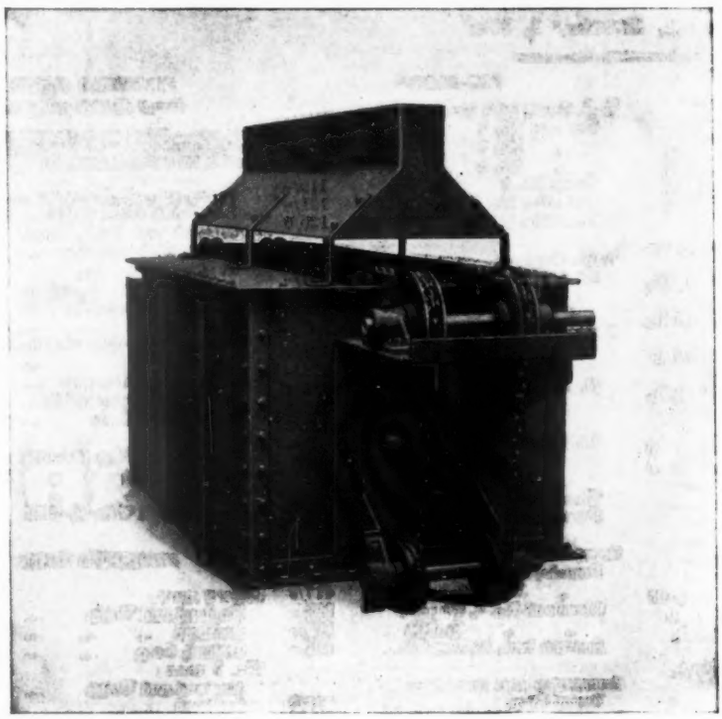
Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"GLACIER"—Metals and alloys. GLACIER METAL COMPANY, LIMITED, 368, Ealing Road, Alperton, Middlesex.

"OXYDA"—Combustion gas flame apparatus for fusing metals and alloys, for uniting metals and alloys for autogenous welding, brazing or soldering, and for the flame treatment of metals and alloys. BRITISH OXYGEN COMPANY, LIMITED, Thames House, Millbank, London, S.W.1.

FOUNDRY & METALLURGICAL—F. & M. S., LIMITED (Device)—Chemical products, tempering substances and chemical preparations, and adhesive substances for uses in industry. F. & M. SUPPLIES, LIMITED, 21/23, Coldharbour, London, E.14.



CONTINUOUS CHAIN FURNACE

FOR LOCAL HEATING, HEATING FOR JOGGLING FISHPLATES, etc., etc.

Illustration shows oil-fired furnace, but any type can be arranged to suit requirements.

FURNACES, STOVES, SAND PLANTS

SPECIALISTS

Latest design Mixers delivered from Stock

COGGON FOUNDRY EQUIPMENT LTD Ovenden HALIFAX

Phone: 2423 Halifax Grams: COGGON, HALIFAX

ON ADMIRALTY, WAR OFFICE, AIR MINISTRY, LLOYDS, AND OTHER APPROVED LISTS.

T. J. LLOYD & CO LTD

Specialists in

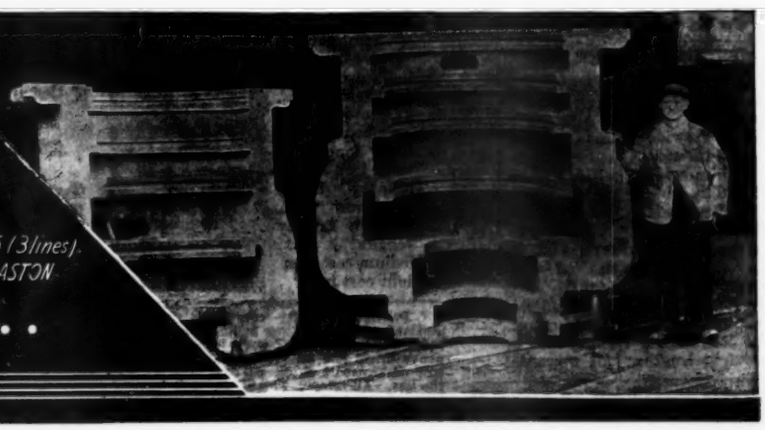
STEEL CASTINGS

From a few ounces up to 25 TONS

FOR ALL INDUSTRIES

JAMES BRIDGE STEEL WORKS near WEDNESBURY ··

PHONE:-DARLASTON 225 (3 lines).
GRAMS:- STEEL DARLASTON



RAW MATERIALS—PRICE LIST

Wednesday, October 2, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent.	60	10	0
Black hot-rolled wire rods	65	10	0

TIN

	£	s.	d.
Standard cash	255	0	0
Three months	259	0	0
Settlement	255	10	0
Official average Cash, Sept.	251	6	10⅝
Do. Three Months, Sept.	254	4	7⅝
Do. Settlement, Sept.	251	7	4¼

SPELTER*

	£	s.	d.
G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
"Prime Western"	26	10	0
Refined and electrolytic	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

	£	s.	d.
Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b.	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b.	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works	39	2	6
Rolled zinc (boiler plates), ex works	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises	28	7	6

ANTIMONY

English, 99%, delivered	90 0 0
Foreign Regulus, duty paid	90 0 0 to 93 0 0
Chinese, prompt shipment, c.i.f.	79 0 0 to 82 0 0

QUICKSILVER

Quicksilver, ex-w'hse London 50 0 0 to 54 10 0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.
Finished bars, 22% tungsten	4s. 4d.

Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3¼ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal.)

	£	s.	d.
Ferro-silicon—			
25%	18	10	0
45/50%	21	10	0
75%	31	0	0
Ferro-vanadium—			
35/50%	15/6 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	6/- lb. Mo.		
Ferro-titanium—			
20/25% carbon-free	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb		
Tungsten metal powder—			
98/99%	5/2½ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	—		
Max. 1% car.	—		
Max. 0.5% car.	—		
70% carbon-free	—		
Nickel—99.5/100%	£190 to £195		
"F" nickel shot	175	0	0
Ferrocobalt, 98/99%	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	0	0
76/80% packed	19	10	0
Metallic manganese—			
94/96% carbon-free	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths	3	16	6	to 3	19	0
Heavy machinery cast iron			4	6	6	
Ordinary heavy cast iron			4	1	6	
Cast-iron railway chairs			4	6	6	
Medium cast iron			3	17	9	
Light cast iron			3	13	0	
MIDDLESBROUGH—						
Short heavy steel	3	14	3	to 3	16	9
Heavy machinery cast iron			4	11	3	
Ordinary heavy cast iron			4	8	9	
Cast-iron railway chairs			4	8	9	
Medium cast iron			3	19	0	
Light cast iron			3	14	0	
BIRMINGHAM DISTRICT—						
Short heavy steel	3	9	3	to 3	11	9
Hematite ingot mould			5	10	9	
Heavy machinery cast iron			4	11	9	
Ordinary heavy cast iron			4	7	0	
Cast-iron railway chairs			4	7	0	
Medium cast iron			3	19	9	
Light cast iron			3	14	9	
SCOTLAND—						
Short heavy steel	3	14	0	to 3	16	6
Heavy machinery cast iron			4	13	9	
Ordinary heavy cast iron			4	8	9	
Cast-iron railway chairs			4	13	9	
Medium cast iron			3	16	9	
Light cast iron			3	11	9	

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

	£	s.	d.
N.E. COAST (d/d Tees-side area)—			
Foundry No. 1	123/-		
,, No. 3	120/-		
,, No. 4	119/-		
Forge No. 4	119/-		
Hematite No. 1	131/-		
Hematite M/Nos.	130/6		
N.W. COAST—			
Hem. M/Nos. d/d Glasgow	131/-		
,, d/d Birmingham	142/6		
MIDLANDS (d/d Birmingham dist.)—			
Staffs No. 4 forge	121/-		
,, No. 3 fdry.	122/-		
Northants forge	118/6		
,, fdry. No. 3	119/6		
,, fdry. No. 1	122/6		
Derbyshire forge	121/-		
,, fdry. No. 3	122/-		
,, fdry. No. 1	125/-		
Phosphorus 0.5% to 0.75%	129/6		
Phosphorus 0.1% to 0.5%	132/6		
SCOTLAND—			
Foundry No. 1, Grangemouth	119/9		
,, No. 3, Grangemouth	117/3		
Cleveland No. 3, Glasgow	123/-		
,, ,, Falkirk	120/-		
Scottish hem. M/Nos. d/d	131/-		
SHEFFIELD (d/d district)—			
Derby forge	118/6		
,, fdry. No. 3	119/6		
Lincs forge	118/6		
,, fdry. No. 3	119/6		
W.C. hematite	136/6		
LANCASHIRE (d/d eq. Man.)—			
Derby fdry. No. 3	125/-		
Staffs fdry. No. 3	125/-		
Northants fdry. No. 3	123/6		
Cleveland fdry. No. 3	125/-		
Cylinder and Refined Irons			
North Zone	168/-		
South Zone	170/6		
Refined Malleable			
Birmingham and S. Staffs	165/6		
Cold Blast			
South Staffs	217/-		

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

	£	s.	d.
BASIC:			
Soft, u.t., 100-ton lots	10	10	0
Tested, up to 0.25% C.	10	15	0
Tested, 0.25 to 0.33% C.	10	17	6
Tested, 0.33 to 0.41% C.	11	0	0
Hard (0.42 to 0.60% C.)	11	17	6
,, (0.61 to 0.85% C.)	12	7	6
,, (0.86 to 0.99% C.)	12	17	6
,, (1% C. and up)	13	7	6
Silico-manganese	14	5	0
Free-cutting	12	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	13	15	0
Case-hardening	14	12	6
Silico-manganese	14	10	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C.	12	2	6
Basic hard, 0.41 to 0.60% C.	12	10	0
Acid, up to 0.25% C.	14	5	0

Other Semi-products, etc.

Tin bars	10	7	6
Sheet bars	10	7	6
*Wire rods, soft basic	15	4	0
,, hard basic	18	12	6
,, free-cutting	17	12	6
,, acid	22	3	6

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections plates, joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast)	14	3	0
Boiler plts. (N.E. Coast)	15	0	6
Chequer plts. (N.E. Coast)	15	13	0
Angles, over 4 un. ins.	13	13	0
Tees, over 4 un. ins.	14	13	0
Joists, 3 in. × 3 in. and up	13	13	0
Rounds and squares, 3 in. to 5½ in.	14	13	0
Rounds under 3 in. to ⅛ in. (untested)	15	8	6
Flats—over 5 in. wide	13	18	0
,, 5 in. wide and under	15	8	6
Rails, heavy, f.o.t.	12	15	6
Hoops	16	3	6
Black sheets, 24 g. (4 t. lots)	19	7	6
Galv. cor. shts. (,,)	22	12	6
Galv. flat shts. (,,)	23	2	6
Galv. fencing wire, 8g. plain	24	7	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales	15	2	6
Scotland	15	2	6
Ireland, f.o.q.	15	15	0
No. 3 BARS:			
England and Wales	12	5	0
Scotland	13	7	6
Ireland, f.o.q.	12	17	6
No. 4 BARS:			
England and Wales	12	15	0
Scotland	13	12	6
Ireland, f.o.q.	13	7	6
STRIP:			
England and Wales	16	10	0
STAFFS MARKED BARS, f.o.t.	18	0	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, August 27, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

Welsh foundry	42/6 to 44/-
,, furnace	31/6 to 33/-
Durham foundry	39/6
,, furnace	33/5
Scottish foundry	42/6 to 47/6
,, furnace	31/6

TINPLATES

f.o.b Bristol Channel ports

I.C. cokes	20 × 14 per box	27/- to 29/-
,,	28 × 20 ,,	54/- to 58/-
,,	20 × 10 ,,	38/6 to 39/6
,,	18¾ × 14 ,,	28/3 to 29/-
C.W.	20 × 14 ,,	25/- to 26/-
,,	28 × 20 ,,	50/- to 52/-
,,	20 × 10 ,,	36/3 to 37/6
,,	18¾ × 14 ,,	26/- to 27/-

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ¼ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basic
Strip	13d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

A COMPARISON OF CAST-IRON SCRAP PRICES

Average Monthly Prices of Cast-iron Scrap in the Principal Districts in the Years 1934–40

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
SCOTLAND (Heavy Machinery)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 14 2	2 17 9	2 18 5	2 18 3	2 15 5	2 15 9	2 14 3	2 15 0	2 15 9	2 15 0	2 15 8	2 16 3	2 16 0
1935..	2 15 5	2 15 8	2 15 10	2 16 4	2 16 10	2 17 0	2 16 9	2 16 9	2 17 0	2 16 11	2 19 11	3 2 7	2 17 5
1936..	3 4 8	3 9 10	3 10 11	3 11 10	3 10 8	3 9 10	3 9 2	3 8 9	3 8 11	3 9 2	3 10 0	3 13 3	3 9 9
1937..	3 15 0	4 2 10	4 6 2	4 9 9	4 14 9	4 15 0	4 15 0	4 15 0	4 15 0	4 15 6	4 15 0	4 13 3	4 11 0
1938..	4 11 3	4 11 3	4 8 3	4 5 7	4 1 2	3 17 10	3 15 0	3 14 4	3 12 7	3 14 10	3 18 0	3 18 0	4 0 8
1939..	3 19 0	3 19 0	3 19 0	3 19 0	4 1 1	4 2 6	4 2 6	4 3 2	4 5 5	4 3 0	4 3 0	4 3 0	4 1 8
1940..	4 3 0	4 3 0	4 13 0	4 13 0	4 13 7	4 13 9	4 13 9	4 13 9	4 13 9	—	—	—	—
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
N.E. COAST (Heavy Qualities)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 12 7	2 15 1	2 13 7	2 11 6	2 11 11	2 13 9	2 11 0	2 10 6	2 11 3	2 11 10	2 13 9	2 13 3	2 12 4
1935..	2 12 2	2 13 0	2 12 7	2 13 0	2 12 9	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 16 10	2 12 10
1936..	3 0 0	3 1 10	3 1 8	3 2 2	3 4 6	3 3 9	3 5 9	3 4 1	3 5 11	3 6 3	3 6 3	3 7 10	3 4 2
1937..	3 10 6	3 14 9	4 2 6	4 3 9	4 6 3	4 7 6	4 7 6	4 7 6	4 6 0	4 5 0	4 5 0	4 5 0	4 3 5
1938..	4 5 0	4 2 6	4 0 0	3 18 1	3 11 3	3 10 0	3 10 0	3 9 8	3 11 0	3 13 1	3 15 0	3 13 6	3 14 11
1939..	4 0 0	4 0 0	4 0 0	4 0 0	4 2 6	4 1 6	4 0 0	4 0 0	4 0 2	4 0 6	4 0 6	4 0 6	4 0 6
1940..	4 0 6	4 0 6	4 10 6	4 10 6	4 11 1	4 11 3	4 11 3	4 11 3	4 11 3	—	—	—	—
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
S. WALES (Heavy Cast Iron)—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1934..	2 6 10	2 8 9	2 7 8	2 6 6	2 7 6	2 8 0	2 6 10	2 6 7	2 8 0	2 8 2	2 9 1	2 11 5	2 7 1
1935..	2 11 3	2 11 4	2 11 1	2 11 3	2 12 0	2 11 1	2 11 1	2 11 0	2 12 2	2 13 10	2 14 5	2 14 3	2 11 9
1936..	2 16 3	2 18 7	2 18 9	2 19 2	2 18 7	2 18 7	2 19 0	2 19 0	2 18 9	2 19 0	2 19 2	2 19 0	2 18 8
1937..	3 4 1	3 9 8	3 9 3	3 9 0	3 9 0	3 9 0	3 9 0	3 9 0	3 8 9	3 9 9	3 9 9	3 9 11	3 8 10
1938..	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0	3 10 0
1939..	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 1 6	3 3 5	3 9 0	3 9 0	3 9 0	3 3 7
1940.. ..	3 9 0	3 9 0	3 19 0	3 19 0	3 19 7	3 19 9	3 19 9	3 19 9	3 19 9	—	—	—	—

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Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY MANAGER, grey iron, desires change, 16 years present position, jobbing and general, member I.B.F.—Box 486, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY MANAGER desires new appointment. Extensive experience on the practical and technical sides of Steelfoundry Practice and Heat-Resisting Steels. At present in charge of a foundry and subsidiary departments. Enquiries as to career solicited.—Box 494, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY MANAGER wanted in the Black Country. Output about 50 tons per week of general engineering grey-iron castings. Salary £300 to £400 per annum, according to experience.—Give full particulars to Box 490, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY MANAGER required for light-casting and stove-plate foundry which includes mechanical moulding plant.—Write, stating age, experience and salary required, to Box 482, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WANTED.—First-class Steel Foundry Foreman for new Electric Steel Foundry in West of England.—Write in confidence, stating age, experience and salary required, Box 484, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WANTED.—Foundry Foreman, preferably experienced in the production of aluminium alloy or non-ferrous metal sand castings, for a small electric furnace foundry in the Midlands district.—Apply by letter, stating age, experience and wages required, to Box 476, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY FOREMAN for North-East Coast Ironfoundry, must have wide experience in production of high-class light castings to fine limits.—State age, experience, also salary required, to Box 478, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WORKING FOREMAN wanted for small Jobbing Ironfoundry in Lanarkshire. State experience and wages required.—Box 488, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

EMPLOYMENT REGISTER

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

ASSISTANT FOREMAN with sound and varied experience on light castings, machine tools, etc., desires position as foreman. Exceptionally good technical training, successful engineering student. Experienced in repetition light castings. Highest recommendations. (392)

MACHINERY

WANTED.—5/6-ton Geared Tilting Ladle.—Box 492, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOR SALE.—Morgan's 600-lb. Lip-Axis Tilting Furnace, adaptable coke or oil-fired, £85 where lying.—H. LANDSEER-BAILEY, 385, Garratt Lane, S.W.18.

THOS. W. WARD, LTD.

Two Rumbling Barrels, arranged for Single Pulley Drive. Dimensions, 24-in. diameter by 40 in. long.

Belt Driven POSITIVE PRESSURE BLOWER, 4-in. inlet aud outlet.

MP4 Belt Driven EXHAUSTING FAN (Keith Blackman), 8-in. outlet, 7-in. inlet.

Write for "Albion" Catalogue

ALBION WORKS, SHEFFIELD

'Grams: "Forward." 'Phone: 26311 (15 lines).

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO. LTD., Station Works, Ecclesfield, Sheffield.

CUPOLAS

2 ft. 6 in. dia., 15-cwt. per hr. Cupolette.

PNEUMATIC MOULDING MACHINES

Macdonald Jolter, table 72 in. by 54 in.

Tabor 16-in. Shockless, table 72 in. by 48 in.

Tabor Portable Shockless Rollover, table 40 in. by 30 in.

Tabor ditto, table 27 in. by 20 in.

Tabor 21 in. by 16 in. squeeze.

Zimmerman Type R.P.W. 2 Jolt Squeeze turnover, table 36 in. by 20 in.

Mumford Type (Jackman) Swing Headpress, 13 in. by 15 in. and 14 in. by 16 in.

Mumford Pneumatic Core Jolters having 15-in. by 20-in. and 12-in. by 12-in. tables.

Britannia No. 1 "Coventry" Pneumatic Turnover Jarr Ram, table 30 in. by 28 in.

50 Air Compressors; 500 Electric Motors, Dynamos, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD, LANGLEY,
Nr. Birmingham.
'Phone: Broadwell 1359.

MISCELLANEOUS

FOUNDRY capacity available for grey iron castings from a few lbs. up to 5 cwts. Ample facilities for fettling and sandblasting. First-class castings guaranteed to stand machining. Capacity at present idle up to 50 tons per week. Enquiries invited and inspection of facilities willingly offered.—BILSTON FOUNDRIES, LTD., Highfield, Bilston. Telephone: Bilston 41406.

WANTED.—Boxes for machine moulding.—Full particulars to H. J. CREESE & SONS, Syston Foundry, Nr. Leicester.

PUBLICATION

RYLAND'S DIRECTORY of the Coal, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades. New edition. Price 42s. cloth bound, 52s. leather.—INDUSTRIAL NEWSPAPERS, LIMITED, 3, Amersham Road, High Wycombe.

'Phone: 22877 SLOUGH

TWO NEW Core blowers for bombs.

36" Cupola by Geo. Green.

54" Cupola by Thwaites.

5 ft. Cupola by Pneulec.

JOLT SQUEEZE "JACKMAN" MOULDING MACHINES, 14" x 16", as new. £90 each.

Morgan 250 lb. Tilting Furnace (Two).

Morgan 600 lb. Oilfired Tilter.

OSBORN JOLTERS 403 and 406 size.

NEW PIT FURNACES 150 lbs. capacity, oil or coke fired. £35 each.

NEW SHOTBLAST CABINET PLANTS with motor driven Exhaust Fans, complete, all sizes. Prompt delivery.

ALEX. HAMMOND, *Foundry Machinery Merchants.*
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BUY FROM ME AND SAVE MONEY.

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PETER — WITH ONE EXCEPTION

With one exception Peter is an ordinary little fellow. Chubby, likeable, just five-and-a-half, full of life and fun and on occasions—be it admitted—of naughtiness.

Just now Peter's rather important, for this is his first term at school, and he's grappling with the intricacies of "A B C" and "Twice-Two": difficult subjects to all men of five-and-a-half, but even more difficult in Peter's case because—bad luck—he's totally blind. That's his One Exception.

Peter learns reading, writing, and 'rithmetic through the medium of "Braille"—dull stuff compared with the coloured picture books of most five-and-a-halfs. However, he's a stout lad is Peter, and he's making great progress.

Would you like to know more about him? How, in spite of his "One Exception," he is being educated and, when older, technically trained and usefully employed.

There is a long waiting list of "Peters" throughout the British Isles, for whom training and accommodation must be provided in the immediate future.

Will you help with a donation or annual subscription? Any sum, large or small, will be gratefully received.

Here's a suggestion. Your eyesight is worth 3d a year to you. Send Peter and his handicapped pals 3d for every year you've had it. Now, please, in case it slips your memory. Good idea?

The Chairman,
SCHOOL FOR THE BLIND
(Founded 1858)
SWISS COTTAGE, LONDON, N.W.3